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An Advanced Traveler Information System in a Co-Modal Framework by using Multi objective optimization

[1]G.Hema Priya, [2]M.jayapal
[1]M.Tech , Student,[2]Associate .Professor
Department of CSE
Malla Reddy College of Engineering & Technology, Hyderabad

ABSTRACT

We present an advanced traveler information system (ATIS) for public and private transportation, including vehicle sharing and pooling services. The ATIS uses an agent based architecture and multi-objective optimization to answer trip planning requests from multiple users in a co-modal setting, considering vehicle preferences and conflicting criteria. At each set of users' requests, the transportation network is represented by a co-modal graph that allows decomposing the trip planning problem into smaller tasks: the shortest routes between the network nodes are determined and then combined to obtain possible itineraries. Using multi-objective optimization, the set of user vehicle- route combinations according to the users' preferences is determined, ranking all possible route agents' coalitions. The ATIS is tested for the real case study of the Lille metropolitan area (Nord Pas de Calais, France).

I. INTRODUCTION

SHARED transportation services are emerging concepts [5]. In multi-modal transportation users employ at least two different types of means of transport.

Co-modality, instead, arises from the need to convey people on a single means of transport to reduce the impact on environment, costs, and accidents. Hence, co-modality refers to the optimal use of different transportation modes on their own or in combination, taking advantage of ridesharing (the sharing of vehicles by passengers). Information and communication technologies may support the development of advanced tools for passengers allowing the effective integration of transportation modalities [11], [25]. As a result, Manuscript received October 14, 2015; revised March 23, 2016 and August 31, 2016; accepted December 18, 2016. The Associate Editor for this paper was D. Chen. M. Dotoli is with the Department of Electrical and Information Engineering, Politecnico di Bari, 70125 Bari, Italy (e-mail: mariagrazia.dotoli@poliba.it). H. Zgaya is with the ILIS-Lille Institute of Healthcare Engineering, Université de Lille 2, 59000 Lille, France (e-mail: hayfa.zgayabiau@univlille2.fr). C. Russo is with the Magneti Marelli-Powertrain Research, 10135 Torino, Italy (e-mail: cr88fg@gmail.com). S. Hammadi is with the CRISTAL-Research Centre in Computer Science, Signals and Automatic Systems of Lille, École Centrale de Lille, 59651 Lille, France (e-mail: slim.hammadi@ec-lille.fr). Digital Object Identifier 10.1109/TITS.2016.2645278

the field of intelligent transportation systems and particularly of Advanced Traveler Information Systems (ATISs) is rapidly growing [44]. An ATIS may be defined as a system providing pre-trip and real time information on departures, routes, and modes of travel. However, the related literature in the field of passengers' co-modal transportation services is scarce, showing a need for ATISs supporting sustainability-oriented decisions.

This paper aims at filling this gap by a multi-agent ATIS for passengers' pre-trip planning considering co-modal itineraries with multiple preference criteria, taking into account public and private transportation, and including vehicle sharing and pooling. Users request itineraries to the ATIS, with given (eventually different) origin and destination pairs and arrival/departure time windows, specifying their preferences by an ordered sequence of criteria. The ATIS matches requests with information in transportation operators' databases and chooses transportation means and routes. It provides the routes answering requests and optimizing travel time, travel cost, and gas emissions. To the best of the authors' knowledge, no ATIS for trip planning exists in the literature for trip planning both with private and public transport in a co-modal and multi-objective

framework, i.e., with multiple users and preferences. Moreover, with respect to the previous works by the authors, we remark here that the paper enhances and extends three previous contributions [12]. The ATIS architecture borrows the multi-agent systems paradigm from improving the vehicle/operator/route/users association, which is here determined in a stand-alone way without using an external software as in [2] but rather representing, as in the transportation network by a co-modal graph. With respect to however, here two improvements are provided. First, we enhance the trip calculation defining route

agents to represent the possible routes composing the itinerary solution path and employing an agent coalition mechanism to determine the best person-to-vehicle assignment for the concerned route using genetic optimization. Second, the user

can express his preference among different transportation means and define a descending order of priority of multiple criteria (cost, time, and emissions in the case study). Finally, we remark that the paper is a deeply revised version of [12]. Here we detail the multi-agent architecture, only sketched in [12], by describing all the agents operations. Moreover, we enhance the case study presenting a totally new.

II. MULTI-AGENT SYSTEM ARCHITECTURE FOR A DISTRIBUTED CO-MODAL TRANSPORT SYSTEM

The agent computing paradigm is one of the powerful technologies for the development of distributed complex systems. The agent technology has found a growing success in different areas through the inherent distribution which allows for a natural decomposition of the system into multiple agents. These agents interact with each other to achieve a desired global goal. The transport domain is well suited for an agent-based approach since transport systems are usually geographically distributed in dynamic changing environments. Each agent is composed of states, different types of knowledge (environmental, social and personal), messages, behavior rules and a perception function. By using the behavior rule, the agent can modify its state according to current states, knowledge and received messages in order to reach the collective goal.A set of rules and behaviors can define a role. An agent can though have different roles. From a role to another, the agent changes its capabilities and behaviors. According to the problem described above, we propose a multi-agent system based on the coordination of several kinds of software. The architecture of the proposed multi-agent system

In our system, we consider K transport services and Ki transport operators associated to the transport service I (i ∈ [1. . K]. we associate an agent to each transport service and an agent to each transport operator. A transport Service Agent (TSAi , 1 ≤ i ≤ K) is responsible for a set of Transport Information Agent (TISi,j, 1 ≤ j ≤ Ki). Each TSAi,j is able to respond to an itinerary request (x,y, Wx,y) by a shortest path RC∗ I x,y that allows to go from x to y on a transport network of the operator j associated to the service

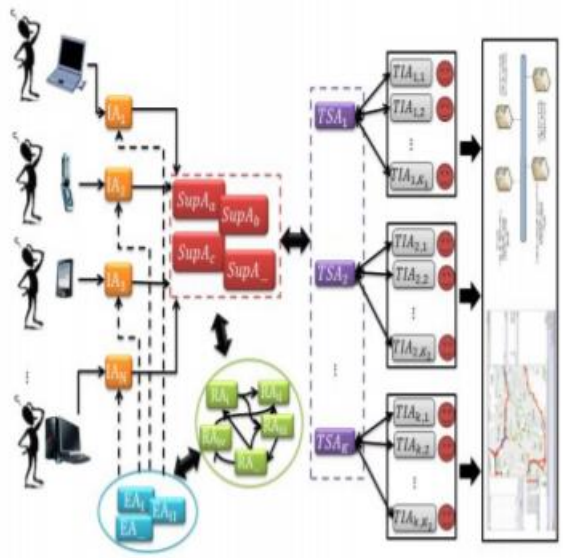

Figure:1.Multi Agent System Architecture

III. SYSTEM ANALYSIS

EXISTING SYSTEM

An interesting work is proposed by Zhang et al. who present an ATIS for multimodal transport considering both private and public transportation, considering time, cost, effort and comfort attributes. However, the approach is devoted to single user trip planning, i.e., it does not take into account the co-modal approach. Moreover, private and public networks are modeled separately and integrated only as a last step, determining the trip by a centralized approach, leading to long computational times. Other works use artificial intelligence approaches to develop an ATIS capable of some adaptability.

Arentze [3] presents an ATIS for trip planning on multi-modal transport networks using

Bayesian inference to adaptively learn the user's preference. However, this approach is devoted to answering single users' requests. More recently, several advanced public transportation information systems have been developed, determining the shortest itineraries in terms of travel time or cost through online web-based applications. However, in all the recalled ATISs the problem is solved by a classical centralized approach and without any co-modality objective. In fact, the discussed works typically consider only a user request at a time.

Disadvantages

- There is no Multi Agent To process pre trip planning.
- There is no pre-trip planning technique.

PROPOSED SYSTEM

- The system proposes a novel Advanced Traveler Information System (ATIS) for co-modal passengers' transportation based on a multi-agent system architecture to answer multi-criteria user requests.
- The multi-agent systems framework is selected due to its distributed feature that allows decomposing the trip planning problem into multiple simpler tasks. The presented ATIS can satisfy multiple requests with multiple conflicting criteria.
- The proposed system shows that if a user changes its criteria preference, the itinerary may change and that this is accentuated for multimodal paths. Moreover, we show that the ATIS is able to propose solutions even when not all transportation means are available, for instance in case of strikes.

Advantages

- The system implemented pre-trip planning considering co-modal itineraries with multiple preference criteria.
- The system provides the routes answering requests and optimizing travel time, travel cost, and gas emissions..

III. IMPLEMENTATION

- **Online Server**

In this module, server has to login with valid username and password. After login successful he can do some operations such View all Users and authorize and View all Locations, List All Added Locations, List All Users, and Comments, List all users, List all transactions.

- **User**

In this module, there are n numbers of users are present. User should register before doing some. After registration successful he can login by using valid user name and password. Login successful he will do some operations like Search Location, Send Interest on Rout, Recommend the Tourist Spot, Find all Other User Search on the same path.

- **Agent**

In this module, there are n numbers of users are present. An agent should register before doing some. After registration successful he can login by using valid user name and password. Login successful he will do some operations like Add Location, Add Location Direction, Add Location Spot Related Video.

IV. CONCLUSION

We propose a novel Advanced Traveler Information System (ATIS) for co-modal passengers' transportation based on a multi-agent system architecture to answer multi-criteria user requests. The multi-agent systems framework is selected due to its distributed feature that allows decomposing the trip planning problem into multiple simpler tasks. The presented ATIS can satisfy multiple requests with multiple conflicting criteria. We show that if a user changes its criteria preference, the itinerary may change and that this is accentuated for multimodal paths. Moreover, we show that the ATIS is able to propose solutions even when not all transportation means are available, for instance in case of strikes. Numerous prospects exist for future research. They may regard using geographical coordinates to define the transportation network, adding some features to allow users change or personalize their path in real time, and minimizing the number of determined sub routes and hence of route combinations to speed up the

ATIS. Moreover, including the proposed planning tool in a real time decision support system may be considered for devising an ATIS for real-time trip planning allowing for traffic guidance and reduction. In addition, we are working on implementing a reward system in our ATIS for incentivizing users choose more sustainable solutions. Further, we would like to integrate within the ATIS several alternative optimization algorithms from which the system may choose dynamically the best algorithm according to the transport problem complexity. Moreover, the ATIS may use responsive user interfaces in order to adapt the information representation, according to the user adopted device.

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