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Traveler Information System to Optimized Journey Using Multi Agent in a Co-Modal Frame Work

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ABSTRACT: Traveller information systems play a significant role in most travellers' daily trips. These systems assist travellers in choosing the best routes to reach their destinations and possibly select suitable departure times and modes for their trips. we present an advanced traveller 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 user's 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 is determined according to the user's preferences, and all possible route agents' coalitions are ranked.

I. INTRODUCTION

A collective transportation services are emerging concepts. 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, which ensures 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. As a result, the field of intelligent transportation systems and particularly of Advanced Traveller Information Systems (ATISs) is rapidly growing. An ATIS is formed 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 of 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. The ATIS architecture borrows the multi-agent systems paradigm for improving the vehicle/operator/route/users association, which is here determined in a stand-alone way without using external software but rather representing the transportation network by a co-modal graph. In addition, here we provide two improvements: 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.

II. The Co-Modal Trip Planning Problem

The scope of the proposed ATIS is to satisfy user‟s requests for itineraries by answering trip requests respecting preferences. To this aim, the ATIS employs the notion of co-modality: combining all possible means of public transport with private transportations services, i.e., using different modes, on their own or in combination to reach an effective and sustainable utilization of resources. To improve sustainability, the ATIS considers multiple operators to offer the same service for each transportation service. We assume that multiple users formulate simultaneously (or in a short time window) a set of requests. Hence, the ATIS determines feasible decompositions of each itinerary or route, i.e., sub routes, by recognizing similarities in order to associate different users to the same vehicle and transportation service (so as to satisfy the co modality requirements). For a given route or sub route, several transportation possibilities may exist with different vehicles, which may all be available for that route through the same time window. The problem is thus to choose the most effective route combination for a given user, taking into account his constraints and preferences in terms of preferred means of transport and conflicting criteria, while considering the co-modality requirements. We adopt an aggregative approach to obtain the most effective solution by a compromise between criteria (transport time, total cost, and total gas emissions). By means of a weighted sum function, the aggregation method reduces the number of conflicting criteria by judiciously choosing the weights combining them into a single optimization criterion so that two conflicting criteria cannot be improved or deteriorated at the same time.

We remark that the optimization criteria of co-modal transport systems are typically multiple and conflicting. They depend on the physical situation (geolocalization of transport means), on the topological configuration of the transportation network, as well as on technical capabilities, institutional capacities, financing support, and political decisions. In addition, passenger‟s preferences usually imply a conflicting situation in order to reach low cost, high quality services, rapid itineraries, comfort, safety and security. Here we choose three classical criteria that are clearly conflicting: travel time, travel cost, and gas emissions. For example, in the carpooling mode, the driver can make a detour to pick up new passengers. This detour increases the transport time and decreases the transport cost. In fact, the total cost of the itinerary is cheaper for each passenger because the total costs involved are shared. Exactly because of the complicated nature of the problem, and due to the presence of conflicting criteria, we propose a multi-criteria decision making ATIS.

III. ATIS Multi-Agent Architecture

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 behaviour 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 is described below (Fig.1).

The ATIS architecture is described by Fig. 1, including: Interface Agents (IA) receiving users' requests; a Super Agent (SA) building and solving the co-modal graph and creating the Route Agents (RA); Transport Service Agents (TSA) searching for transportation means suitable for the requests; Transport Information Agents (TIA) communicating with the transportation operators database; RAs building sub route coalitions; an Optimizer Agent (OA) calculating the best solution for each user request. Accordingly, the workflow in Fig1reports the agents in the different operations.

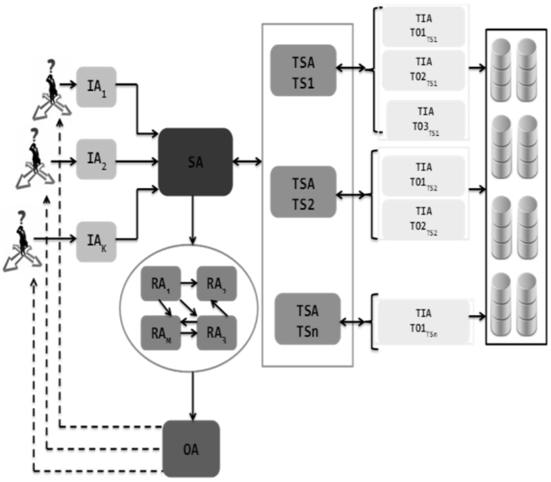

Figure 1. ATIS Multi-Agent Architecture

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∗Ix,y that allows to go from x to y on a transport network of the operator j associated to the service i.

For a global request Ik(dk,ak,Wk)∈It an Interface Agent (IA) interacts with a system user allowing him to formulate his request choosing his preferences and constraints and displays at the end the correspondent results. When an IA handles a user request, it sends it to a SuperAgent (SupA). It is an agent with different important roles. Firstly, this agent asks the TSAs for a search domain and all the transport operators that will be involved in the itinerary research. We assume that the SupAhas a global view of all the TSAs that define the environment. The SupA cooperates then with the set of TIAs identified by the TSAs and starts by constructing a co-modal graph. The SupA decomposes this complex graph into a special graph called "Transfer graph" and a co-modal approach is applied. After a first computing of the shortest paths in terms of time, the SupA generates all possible Route Combinations from simultaneous itinerary requests thanks to the Route Agents (RA). All the roles and the tasks executed by the SupA are detailed in the next sections.

The RA represents a generated chromosome scheme called VeSAR for an identified useful Route Ik(dk,ak,Wk)∈It in order to assign concerned users to possible vehicles. As soon as each RA assigns persons to vehicles, updating the number of passengers in carpooling vehicles and the number of available vehicles of free use vehicle service, it computes all values criteria of each vehicle for each assignment. A multi-agent coalition is then created regrouping all RAs corresponding to a possible Route combination for a given itinerary. Therefore, we have as many coalitions as combinations knowing that an RA can belong to many different coalitions according to combinations overlapping. Coalitions appear and disappear dynamically according to requests receptions and responses.

IV. MODULES DESCRIPTION

MODULES:

- ATIS Workflow
- ATIS Multi-Agent Architecture
- Description of the ATIS's Agents
- The User/Vehicle Assignment

ATIS Workflow:

The ATIS receives the requests by *K* users. Hence, a domain is performed to identify the transportation means available for the requests and the co-modal graph representing the transportation network is built. Then, from the co-modal graph, a transfer graph is built, composed of a set of uni-modal networks called components, connected by arcs that model the change of transportation services. The transfer graph is solved by computing the intra-component paths, i.e., all the shortest paths (in terms of travel time) among particular points. We remark that, in a transportation network, position points are represented by a number of nodes related by a set of vertices. In our work, a shortest path involves the minimum number of vertices between points. To find the shortest path between these points, the weight or length of a path is calculated as the sum of the weights of the edges in the path. So, a path is a shortest path if there is no path from the two points with lower weight. The shortest path is considered as a small size optimization problem, so we can use directly an exact method such as Dijkstra's algorithm to optimize locally criteria as the travel time, total travel cost, etc.

ATIS Multi-Agent Architecture:

The paradigm used to implement the ATIS is that of Multi-Agent Systems (MAS). An agent is a system perceiving the environment by sensors and impacting it by actuators. A MAS is a system made by several agents interacting with each other. In MASs, two main categories of interactions among agents exist: cooperation and negotiation. Negotiation occurs in case of conflictual goals (antagonist agents). Cooperation is a form of interaction between autonomous and rational entities, called agents, to jointly solve tasks or maximize utility. This notion is one of the key concepts differentiating Mass from other related disciplines such as distributed computing, object-oriented systems, and expert systems. Further, each agent is composed of states, different types of knowledge(environmental, social and personal), messages, behaviour rules(i.e., a list of tasks) and a perception function. Thanks to the Behaviour rule, the agent can change state according to current states, knowledge and received messages in order to reach the collective goal. A set of rules and behaviorscan define a role. An agent can have different roles, but it can run just one at time. From a role to another, the agent changes its capabilities and behaviours. Each agent knows only its information. To exchange the information and achieve a desired global goal, agents can send and receive messages labeled *MESSAGE* between each other.

Description of the ATIS's Agents:

The IA is the agent that communicates with users to read their requests. Through the ATIS interface it is possible to choose also the preferences of the criteria: the weight of each criterion for the optimization phase is assigned according to this choice. This agent has a simple behavior: it receives the requests and it sends them to the SA.The SA is the ATIS core and the most complex agent, having three roles. The first role is to define the domain search by communicating with the TSAs that in turn each communicate with their TIAs. The SA sends a message to the TSAs, with the departure and arrival points of the requests that it received by the IAs.

The User/Vehicle Assignment:

The final user/vehicle assignment is made by a Genetic Algorithm (GA). GAs are parallel stochastic search methods to solve problems, imitating Darwinian evolution laws, based on a simple iterative scheme. The reason for this choice is the diversity and the efficiency of population-based techniques: a GA initializes and progressively let evolve population of solutions of the problem appropriately encoded in a pre-selected alphabet. The fitness of each individual(solution) in the population is then computed. The fitness value rules the iterative search schema, which is performed in two subsequent phases: selection and recombination. After these, a new population (offspring) is ready for fitness evaluation. By iteration of this search schema, the GA converges toward better solutions in a wide class of hard numerical optimization problems.

V. CONCLUSION

A 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.

VI.REFERENCES

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