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Thesis Proposal

Title : Multimodal trip allocation in a MaaS framework based on adaptive multi-agent systems

Référence : **TIS-DTIS-2024-XX**
(à rappeler dans toute correspondance)

Thesis start date : 01/10/2024	**Application deadline : 30**/04/2024

Key words : Mobility-as-a-Service, Multi-Agent Systems, auctions, multimodal transport, simulation

Profile and required skills

5 years' higher education with a specialisation in AI or MAS

Thesis Project Presentation

1. Context of the study

As part of the Occitanie region's "Intelligent and Sustainable Mobility" key challenge, we are investigating the concept of Mobility-as-a-Service (MaaS) to improve user's interactions with developed services and to change people's travel behavior by nudging them to make sustainable choices. A key point in encouraging this change is personalization of services to adapt them to the needs of the user and thus encourage user acceptance [3]. Initial work carried out as part of the Vilagil project's MaaS action has led to the implementation of a system for detecting a user's travel patterns and learning their travel preferences. The aim of this is to offer users equivalent routes that are more virtuous while respecting their preferences and needs.

To achieve this, it is necessary to have an itinerary generator that combines different modes of transport, including private bicycles and vehicles. Several route generators currently exist. Most of them combine means of transport with fixed departure and arrival points and predefined timetables, such as the metro, bus or shared bike. Generating multimodal itineraries integrating personal means of transport is a highly complex problem due to the increase in possible combinations, the uncertainty of departure times, taking into account last-minute events that can cancel a planned journey, particularly in the case of car-sharing.

In this context, it is necessary to define an open, flexible and robust route generator able to quickly adapt to the high level of dynamics inherent to this type of applications.

2. Thesis Objectives

The aim of this thesis is to enable users and transport services (CAV, carsharing, carPooling, TAD, Bus, Metro, etc.) to coordinate in a fluid, decentralized manner to determine possible user-service allocations (or service compositions, in the multimodal framework). Users can thus offer their car as a means of transport at any time. The system can then integrate them in real time and propose their car-sharing as new means of transport for other users.

We propose to address this problem based on the concept of adaptive multi-agent systems, coupled with the principle of decentralized auctions [1,2], notably dedicated to multi-agent and multi-modal tasks [5], or distributed optimization protocols [6], where each service will be associated to a cost and each request to a criticality. The definition of these measures should take into account different granularities, from simple trajectory modification to ecological impact.

System validation must take into account the impact of multimodality on travel quality and cost reduction, using various existing (NYC cab, Tisséo, etc.) or generated data sets. Work with urban planners and economists is intended to validate the system as a decision-making tool for moving towards a flexible, multimodal transport offer that takes user needs into account.

3. Provisional schedule

The work plan for this thesis is as follows:

- Understanding the problem, existing solutions, and literature review
- Formalization of the multimodal route generation problem
- Formalization of the multimodal trip allocation problem and development of resolution algorithms
- Performance evaluation / determining the impact of multimodal trajectories / Cost evaluation by modality and study of the benefits of multimodality on behavior change
- Definition of games and testing methods
- Conducting tests and experimental evaluation using GAMA
- Writing articles and the manuscript

4. Bibliography

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[2] Choi, H.-L., Brunet, L., and How, J. P., "Consensus-Based Decentralized Auctions for Robust Task Allocation," *IEEE Transactions on Robotics*, vol. 25, Aug. 2009, pp. 912–926.

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Planned Collaborations Elsy Kaddoum (IRIT, UPS)

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