Intelligent Environments 2018
I. Chatzigiannakis et al. (Eds.)

doi:10.3233/978-1-61499-874-7-441

Agent-Based Architecture for Travel Agency

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Abstract. In recent years there has been an increase in tourist demand in Portugal, mainly in the north. When a tourist arrives the first time to a new place, he needs to do an exhaustive research on the region or receive recommendations through applications that exist in the market. TheRoute has as an objective the development of a recommender system of touristic routes, with special focus on the northern region of Portugal, but it can be used in other regions of Portugal or in other countries. It's an investigation project that has as an innovator aspect the recommendation of routes based in the personality traits os the tourist, and also takes into account the information of the context of the tourist and the surrounding environment. To accomplish these objectives where implemented two algorithms, one that aggregates preferences and one that makes the group formation. The proposed objectives were accomplished with the development of the preference aggregation algorithm and with the group formation algorithm.

Keywords. Recommender System, Preference Aggregation Algorithm, Multiagent System, Tourism, Group Formation Algorithm

1. Introduction

Nowadays people prefer when their job gets simplified, or by getting access to more information or by some software that automates the processes they are working on, and smart workplaces have the objective to do both. It is a type of Ambient Intelligence.

Tourism is when someone travels to a location other than the one she lives in and does it by the means of pleasure or work. This work focus on the tourists that travel by pleasure and when tourists are looking for a vacation programs, they go to Tourism Agencies to seek help in finding one suitable to the individual/group. What Smart Tourism Agencies aim, is that tourists may be able to get recommendations without leaving the house and simplifying the options to the ones they really like.

There are several systems that make tourism recommendations, like INTRIGUE [1], the Travel Decision Forum [2], the Generalist Recommender System Kernel (GRSK) [3] or the Collaborative Advisory Travel System (CATS) [4], but these systems do not incorporate the personality traits in the recommendation process [5]. And this is where this project enters the scenes. The project TheRoute was developed with the objectives to bring the recommendation of routes and the group formation of

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tourists to a new level. Those recommendations are based on the personality traits of the tourists, and also takes into account the information of the context of the tourist and the surrounding environment. The system has two types of end users, and so two types of platforms, the tourists, that will use one of the platforms to obtain routes to visit and the other platform will be used by tourism agency agents, with the purpose of making thematic routes, or forming group of tourists to organize visits.

The work this paper focus is the multiagent system that is used to aggregate the preferences of a group of tourists with the assistance of an algorithm of preferences aggregation. There is an algorithm that is oriented to groups formation in the way that each member of the generated groups has similar preferences with the other members, thus enabling better visit experiences to a city or location. In this paper it is explained what architecture the multiagent system has, and the behaviors of each agent in the system, followed by the explanation of the algorithms used to solve the problem.

The proposed objectives were accomplished with the development of the preference aggregation algorithm and with two versions of a group formation algorithm in which each of the versions are explained in the paper.

2. Group Formation Algorithms

For the group forming problem there were studied some algorithms that are common in group forming problems. The first being studied was the k-means clustering algorithm [6], that works by generating clusters and then forms groups based on the clusters, the algorithm generates the best solution to the problem but takes a great toll in computing time. Other algorithm studied to the case is the genetics algorithm [7], where it generates a starting population of solutions and with an evaluation method it testes the solutions and crosses them to generate another generation of population, until the termination condition is met, the algorithm will generate more generations. When the generations stagnate, there is a mutation in the next generate so the stagnation doesn't continue. The last studied algorithm was the Greedy [8], the algorithm operates by forming groups through the evaluation of the Points of Interest, then groups the users by the ones that have higher evaluations for the same top-k set of Points of Interest.

3. Preferences Aggregation Algorithms

The algorithms that are design to make aggregation of the preferences of the members of a group were found mostly in systems that already exist in the market, systems like CATS where the evaluations of each Point of Interest by the users are joined using an arithmetic mean [4] or in the case of Travel Decision Forum, that each user specify their preferences, the system generates and presents the recommendations and then the users discuss between them which recommendation to take and if consensus is missing they can choose no alternative [2].

These systems weren't a solution that fits this project, this project needs an algorithm that is autonomous, where the users don't have to interact with the system to get a valid solution, and it is needed an algorithm that goes beside an arithmetic mean. For this problem was found an algorithm that fits these two conditions, the Negotiable Alternative Identifier, that selects the most preferred alternative of the group by using the evaluations each user has of the Points of Interest that exist [9].

4. Developed Method

4.1. Problem Definition

When the analysis and the design of the software was created, the first that was made, was the modeling of the tourists and of the points of interest. So, these two are composed as the Table 1 describes.

Table 1 – Modeling of the Tourist and the Point of Interest

Tourist	**Point of Interest**
Name	Name
Date of Birth	Description
Categories	Categories
Personality	Latitude
Agreeableness	Longitude
Conscientiousness	Average Visit Time
Neuroticism	Rating
Openness	Limitations
Extraversion	Opening Hour
Limitations	

After this modeling, we reached a conclusion, that these problems were multicriteria problems, where for the preferences aggregation problem (Table 2), the criteria are the Categories that the tourists like and their personality and as for alternatives, the evaluation of each Point of Interest.

Table 2 - Preference Aggregation Multicriteria Problem Definition

Preference Aggregation Problem	
Criteria	Alternatives
Categories Likes	Points of Interest
Personality	Evaluation

And as for the group formation problem (Table 3), the criteria are the Categories that the tourists like and their personality and as for alternatives, the evaluation of each Point of Interest and the Thematic Routes, that are composed by a set of Points of Interest.

Table 3 - Group Formation Multicriteria Problem Definition

Group Formation Problem	
Criteria	Alternatives
Categories Likes	Points of Interest Evaluation
Personality	Thematic Routes Evaluation

4.2. Multiagent System Proposed Architecture

The multiagent system follows a simple architecture (Figure 1), where there is an agent that is always running and that is responsible to create the other agents. This agent, the Receiver agent, behaviour starts by receiving a request to generate a route to a group of tourists. Then the agent will request all the data of the tourists and the Points of Interest available in the region. Then he will create a number of Tourist agents equal to the number of tourists in the group and each agent will represent one tourist of the group. The next agent to be created is the Tourist Agency agent, that will generate the solution to the group problems, this agent to obtain the solutions, it uses the preference aggregation algorithm and the route generation algorithm that is an ongoing part of our system.

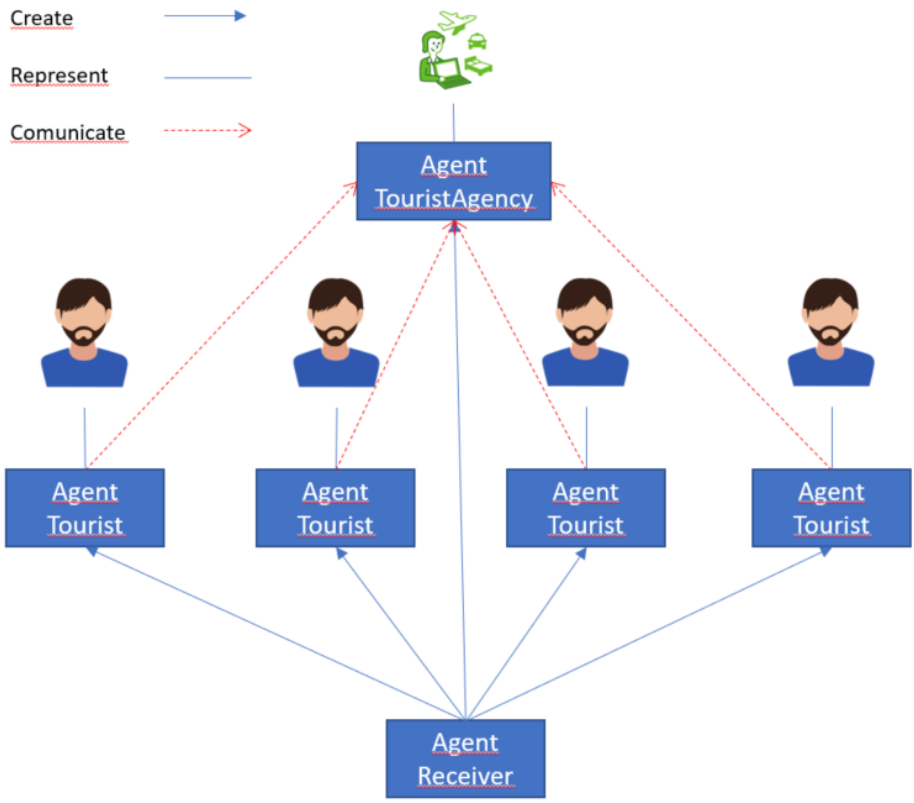

Figure 1 – Multiagent System Architecture

4.3. Proposed Algorithms

Before choosing the algorithms that would be implemented, there was a need to define the Use Cases the system needed to implement, so we made and analysis of the problem. The defined solution, as described in Figure 2, is (1) Route generation for a

group of tourists, (2) Group formation for two or more thematic routes, (3) Group formation with generation of dynamic routes and (4) Group formation for one thematic route.

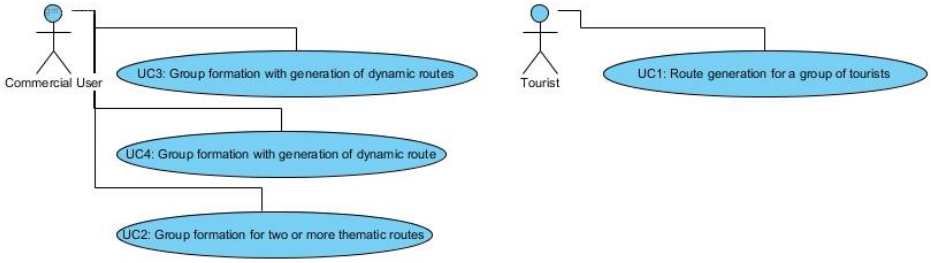

Figure 2 – Use Case Diagram

For the development of this project we chose one preference aggregation algorithm that based on the existent Points of Interest evaluations, it could give a set of Points of Interest that the group members have preference in visit. After the analysis of the systems or algorithms detailed in section 3, it was chosen the Negotiable Alternative Identifier. But the algorithm had to be adapted to our problem and it had to suffer changes. Those changes happened in the algorithm's third phase, where the solution had to return a set of alternatives instead of one alternative. Besides the preferences aggregation algorithm there is the need for a group formation algorithm that can be easily adapted to different types of sets. The case where there is a group formation for thematic routes is different from the one that after the group formation there will be a route generation, and so after the analysis, in section 2, the best algorithm that fits the parameters is the Greedy Algorithm. Since this algorithm uses a matrix of evaluation to form the groups, it is adaptable to what is being evaluated in the matrix, if it is Points of Interest or thematic routes.

4.4. Development

The software that is being developed to the project TheRoute follows a module based architecture where there is a Front-Office for the clients, a Data Access Layer that manages all the communications, the Data Base to store the data, the Decision Support Module where all the algorithms and software business is located and the Back-Office where the administrator, the content managers and other non-tourist users access to manage all kinds of information.

The algorithms mentioned in 4.2 and the multiagent system are implemented in the Decision Support Module. There is a service for each use case in the module, and next it is explained the flow of the use cases.

The first use case starts by receiving a request of the Data Access Layer, the receiver of this request is the first agent of the multiagent systems. The message is sent in JSON and carries some of the needed information for the case to function, the IDs of the users in the group, the latitude and longitude of the starting point, the weekday when the route will be executed, the starting hour and its duration and the mode it will be executed (by foot, car or public transportation). Therefore, the agent will request all the tourists received information and the Points of Interest of the location. After all the information is gathered, the agent will create all the Tourist agents with the information

of the assigned tourist and start executing the tourists, and in the end creates the Tourist Agency agent, that will give the set of Points of Interest that the group most prefer by using the preference aggregation algorithm. This algorithm is one adaptation of the Negotiable Alternative Identifier [9] with an alteration in the phase 3, which the original algorithm selects only the alternative the group most prefer and it was changed to a set of the most preferred. The last step is to generate the route using the route generation algorithm and send it to the Data Access Layer.

The next use case, the group formation for two or more thematic routes, the way it receives information is similar to the previous one but the information that comes with it is different, besides the list of the users IDs it comes with the thematic routes IDs. After requesting and gathering the remaining information, it is executed the group formation algorithm the algorithm is one adaptation of the Greedy algorithm that is described in [8], the changed that was need to make is that the alternative, instead of being one Point of Interest, it is a route, and a route has multiple Points of Interest, so it is used to the formation, the average of the evaluations of the Points of Interest in each route.

The third use case, the group formation with generation of routes, it starts, like the others, by receiving a request of the Data Access Layer, and then requesting the remaining information to the Data Access Layer. After that it executes the group formation algorithm but a different version, that receives a list of Points of Interest that the tourists will evaluate and then will form the groups according to those evaluations. After the group formation it will start for each formed group a process similar to the first use case, where first will be executed the preferences aggregation algorithm and then the route generation algorithm.

The last use case is, the group formation for one thematic route, is similar to the previous use case with the difference that instead of a list of Points of Interest of the location, it will use the list of Points of Interest of one route.

5. Conclusions and Further Work

The proposed objectives in the beginning of this paper were accomplished, where the multiagent system is functional and works, besides that, the proposed algorithms were successfully implemented and properly tested so they would give the better possible solution to the end user. Despite these functional tests, it is still necessary to carry out testes/study of satisfaction on the tourists that will use his software. This project has a prosperous future in the area, if after making case studies with end users, the feedback is positive. As for future work, there are still some areas that can be explored and that need investigation, the next step is improving the multiagent system, so it implements a negotiation mechanism that makes the preferences aggregation more automatic, where each agent represents a tourist and its preferences and defend his interests, negotiating with the other agents. One of the other future objectives is to make a virtual visit of the planning route that is generated for the tourist, where the tourist can have a trailer of the route he is going to make, and if he doesn't like the visit he can always make changes.

Acknowledgments

This work has been supported by COMPETE: POCI-01-0145-FEDER-007043 and FCT - Fundação para a Ciência e a Tecnologia within the Project Scope: UID/CEC/00319/2013 and UID/EEA/00760/2013.
We thank the FCT, the Operational Programme of North Region of Portugal (PO-Norte), and the FEDER Programme, for the selection and support for the project TheRoute - Tourism and Heritage Routes including Ambient Intelligence with Visitants' Profile Adaptation and Context Awareness (project reference SAICT/023447). We also thank Santander-Totta Bank (BST), from Portugal for the fellowship to Rodrigo Mesquita involved in TheRoute.

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