Multi-Agent System for Personalised and Context Related Info-Mobility Services

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Abstract

Within IM@GINE IT EC co-funded project, a Multi-Agent system (MAS) is developed, that can search for and retrieve not only static but also dynamic data, from a wide range of databases and sources, with traffic, touristic and transport mode related and routing information. Thus, information is provided to the user, for obtaining location-based, intermodal transport information services, promoting in this way seamless transport. Furthermore, the system shows to the traveler information about specific points of interest along his/her route. The Multi-Agent system recognizes user preferences according to users profile and even learns them through the history of service provision, the traffic transportation mode used and the overall context of use. In this paper, the algorithm that is developed for the personalization of the service provision is presented, followed by the technical characteristics and the functionality of the developed Intelligent Agents that compose the Multi-Agent system.

1 Introduction

Intelligent user assistance is an emerging trend in modern information systems development. The need for it stems from the fact that users have so many options and opportunities when using modern systems that it is difficult for them to undertake even simple tasks. The ability of the user to modify services even in the smallest detail offers him/her the disadvantage of having too many fields to fill in for a simple query. Therefore the information systems need to intelligently assist the user by automatically filling in trivial information and by hiding unnecessary detail or complexity to inexperienced/not demanding users.

Furthermore, in the infomobility services sector, driving and travelling needs are not static, but dynamic, depending upon the context of use, as defined in detail in DRIVABILITY driver behavioural model (Bekiaris, Amditis & Panou, 2003), which is currently being extended to a traveler behavioural model. Moreover, existing infomobility services are only local, incomplete and offered by varying user interfaces and service delivery platforms. IM@GINE IT project, that started in January 2004 and has a duration of 2 years, aims to develop one and single access point, through which the end user can obtain location-based, intermodal transport information (static and dynamic), mapping and routing, navigation and other related services everywhere in Europe, anytime, taking into account his/her personal preferences. Thus, IM@GINE IT targets the facilitation of seamless travel in Europe.

The services that are developed, support the user throughout the complete travel chain, i.e. from the point of origin to the point of destination. Thus, all the modes of travel are included, i.e. pedestrian, car drivers, public transport (bus, train, metro), taxi stations and airports. The service includes not only information on the optimal (which is different per person and user type) way to travel (i.e. which transportation means to use and their departure/arrival time), but also points of interest (POIs), such as museums, theatres, restaurants, etc.

Personalisation of services is of great importance to the enhancement of safety for all road users. For the in-vehicle use, the information that is displayed on an in-vehicle device can increase dangerously the driver’s workload, having in this way implications to traffic safety. Until now, in-vehicle information communication systems (IVICS) are working as stand alone devices and without taking into account the preferences and/or special needs and requirements of the drivers. Important initiatives have been launched in order to cover the problem of the integrated and holistic management of all the systems/sensors within the vehicle and of the optimised presentation of information to the driver. IM@GINE IT aims to reduce driver’s workload (that is caused e.g. by performing complex tasks like route planning, etc.), creates and updates the user profile (personalised services) in order to adapt the information to the real needs and wants of the driver. Furthermore, by optimising the information provision to pedestrian and public transport users, the MAS will reduce their workload and enhance their safety (they constitute the bulk of Vulnerable Road Users).

In this paper, the algorithms and system functionality are presented, that allow the user to use the IM@GINE IT services even with a single click, while ensuring that he/she gets the expected service from a system that learns his/her habits and preferences. The work that started in the IMAGE project (the predecessor of IM@GINE IT, see Moraitis et al, 2003) is included, which is now complete and mature. In section 2, the use cases of the IM@GINE IT system are briefly presented, followed by the methodology for achieving the goals of IM@GINE IT. In section 3, the learning algorithms are given, while section 4 offers an architectural view of the multi-agent system. Finally, section 5 presents some concluding remarks, focused mainly on further steps towards the oprimisation of the algorithm and the MAS.

2 Methodology

Initially, the use cases of the complete IM@GINE IT system were defined. In Figure 1, the generic use case diagram is displayed. The diagram shows the external objects that interact with the system and the use cases in which they are involved.

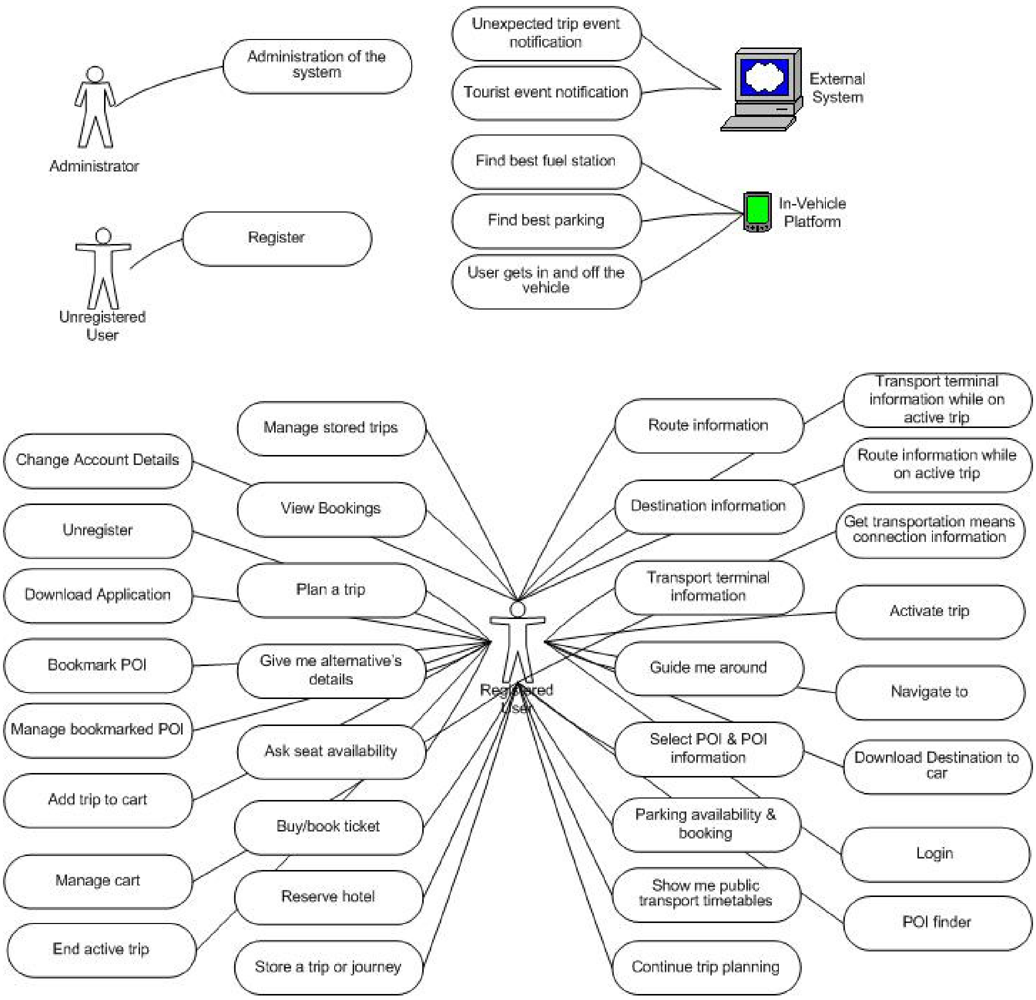

Figure 1: Generic Use Case Diagram of IM@GINE IT (Mizaras et al., 2004).

The focus is on those use cases that are of interest to this paper. The term POI (point of interest) refers to locations such as theatres, banks, museums, etc. Notice the user's ability to "bookmark POI" and his ability to select to "navigate to" a POI.

Based on the use cases, the following scenarios of use were identified:

- Plan a new journey from origin, i.e. home (pre-trip).
- Plan a new journey while on trip.
- Plan a deviation to an existing trip.
- Bookmark or activate a planned journey.
- Ask for supporting services to trip execution (for example navigation according to planned route).
- See details of a bookmarked or active journey.
- Push events that may change the details of the active journey.

During the editing of these scenarios it was determined that the user would need to provide information to the system whenever he/she used the "plan a trip" and "guide me around" use cases, that were implemented as IM@GINE IT services:

- Guide me around service. The user asks "where am I" and he expects to get a map with him/herself on and points of interest relevant to his/her profile around. He/she can ask for information of specific POIs around (e.g. hotels around me) or he/she can make a question for a place to which he/she will be in the future (e.g. I wonder what will be close to me when I arrive at the train station at that city). Personalisation is used and POIs around the user are presented proactively (in the case that the user hasn't selected to see a specific type of POIs around). Moreover, if the user has an active trip, the route part can be seen as it can fit in the resulting map.
- Plan a trip service. The user can simply specify the destination (e.g. an address or one of his/her bookmarked POIs) or select one of the POIs shown after the use of a "guide me around" service. The system provides the user with a route towards a destination that best fits his/her profile and habits. It is also possible to make routing requests for remote cities.

For all the above scenarios, there are three possible priorities, based on which the user requests information for the route and transportation means to use, in order to reach the defined destination:

- fastest route;
- lowest cost route;
- all possibilities.

The developed multimodal behaviour profile personalization algorithm refers to the selection 'all possibilities', as there is no need for personalization if the user selects the first or the second option, since there will be only one proposed route in each case.

3 Personalisation algorithm development

It is important to distinguish the user types that will use the IM@GINE IT system. Thus, the following categories have been identified:

- Tourist (person in a new city/foreign country, traveling for recreation purpose).
- Commuter (person in his/her own city, traveling to/from his/her job).
- Businessman abroad.
- Pleasure traveler, at his/her own city.
- Emergency transport (person in his/her own city/country that needs to travel for emergency reasons, such as sudden illness).

As can be easily understood, the profile of a user that is stored in the system, will change when the type of use changes for the same person, as the needs for type of information provision differ substantially depending on the reason for traveling. This means that a traveler has different needs if, for example, the reason for travel is recreation or business and if he/she travels in a foreign country or new city or within his/her own.

The development of the algorithm is realized in three steps that follow below.

3.1 Step 1: Multimodal behaviour profile personalization

As it was mentioned above, the algorithm is active only when the user selects the 'all possibilities' option for reaching the desired destination.

As a starting point, the number of alternative routes per request that are proposed by the system must be defined (*NR*). Following this logic, the total number of times in service delivered so far, that at least 1 solution with *i* modes is given can be indicated as *T(NE)i*. It can thus be stated now that:

$$\text{If}$$
$$T(NR)i > T(NR)i\ lim \quad (1)$$
$$\text{and}$$
$$S(NR)i < S(NR)i\ lim \quad (2)$$
$$\text{then}$$
$$(NR)i \rightarrow Go\ to\ \text{'reserve list'} \quad (3)$$

The above loop is performed for *k* times.
Where:
NR = number of alternative routes per request,
i = number of transportation means, for each route proposed,
(NR)i = solution with i modes, that the system gives,
T(NR)i = total number of times in service delivered so far, that at least 1 solution with i modes was given,
K = 1, …, SI
SI = service index (each time the user asks service *SI* = *SI* + 1)
S(NR)i = solution selected each time by the user.

Currently, the algorithm is being tested with different values of *T(NR)i lim* (in Equation 1) and *S(NR)i lim* (in Equation 2), aiming to specify the optimum thresholds. Equation 3 means that the solution with i transportation modes that is given by the system will be removed from the 'main list' and it will be visible when the user accesses. the 'reserve list'. If however the users requests *(NR)i* even one time, it is transferred back to the main list of solutions. Of course this is valid only if *(NR)i+1* is in the reserve list, i.e. if a solution given by the system with more transportation means is not in the 'reserve list' but in the 'main list', the *(NR)i* will stay in the 'main list' as well.

3.2 Step 2: Personalisation of POIs

As POIs categories, restaurants, hotels, museums, banks, hospitals, sport venues, parking place, health care centres, tourist information, etc. are considered, which differ among the five pilot sites of IM@GINE IT, where the final system and services will be tested.

This algorithm is independent of user type, as these specific preferences are considered static. The algorithm for this step follows the same logic of the one written in step 1, thus it is not given again (i.e. it depends on the number of times that the system proposed a specific restaurant to the user and the number of times that the user selected the proposed POI type). Of course, separate algorithms are needed for restaurants, hotels, etc.

3.3 Step 3: Personalisation of pushed services

A list of POIs to be used as pushed services has been devised (e.g. specific type of museums, landscapes, shopping centres, etc.). With the term 'push service', information about the existence and location of specific POI types (e.g. modern art museum) without the user asking for it, is meant here. Of course, the pushed services are POIs that the user has asked for in the past, thus the system knows that these correspond to user preference and interests.

The total number of POIs (any) that the user asked for (denominated as TP), each time he/she uses IM@GINE IT (i.e. number of times he/she asked for a POI) and the number of requests for the specific POI during these services (denominated as (RP)j; i.e. number of times the user asked for a specific POI (denominated as j)), are the parameters that compose the following algorithm:

If
$$(RP)j > (RP)j\ lim \quad (4)$$
and
$$\frac{RP}{TP} > \left(\frac{RP}{TP}\right) lim \quad (5)$$
then
$$(RP)j \rightarrow \textit{Go to the 'list of pushed services' to be shown to the user} \quad (6)$$

Where,
TP = total number of POIs (any) that the user asked for, each time he/she uses IM@GINE IT (i.e. number of times he/she asked for a POI),
(RP)j = number of requests for the specific POI during these services (number of times he/she asked for e.g. modern museums).

Similarly with the limits of Equations 2 and 3, tests are in progress for the specification of the optimum thresholds of *(RP)j lim* in Equation 4, i.e. the minimum number of times that a specific POI has been asked and $\left(\frac{RP}{TP}\right) lim$ (the minimum number for the ratio of specific asked POI *(RP)j* over the total number of services asked by the user *TP*). of Equation 5. The above algorithm means that if the user asks a specific POI *(RP)j* more times that its limit (Equation 4) and the ratio of the number of times of the asked POI over the total number of services requests of the user by the system *TP* (Equation 5) is bigger than its limit, then the specific POI *(RP)j* will be put in the 'list of pushed services' of the system.

Also, if the user neglects the specific push service *(RP)j* more than *X* times *(X>Xlim)* and $\frac{RP}{TP} > \left(\frac{RP}{TP}\right) lim$ then the system re-starts the learning for the specific POI, taking it temporarily out of the list of pushed services. The POI-related preference will be re-determined constantly, based upon user requested services.

4 Multi-Agent system (MAS)

The IM@GINE IT MAS is composed of an original combination of four agent types that offer the personalised services, each dedicated to a specific task:

- the personal assistant agent (PAA) works exclusively for one user, handling his/hers personal preferences and adapt the offered services according to the user needs. This agent type will aggregate the simple services provided by other agents in order to offer to the user the IM@GINE IT complex services.
- The transport mode agents assists the user's travel depending on the mode that he/she will use (car, public transport or foot). He is capable of intelligently determining the user's mode using the user's speed and a set of rules.
- the middle agent participates to the localization of services proposed by different provider agents as well as to the transaction achievement between the PAA and the chosen provider agent.
- the provider agents either provide simple services offered by simple service and middleware providers, or provide added value services. Thus, they will be able to perform ticket reservation, plan urban or intercity trips, provide tourist and traffic information. Moreover, they can service specialised user requests in order to perform filtering of large data on the server side.

The agents were built using the JADE/LEAP (Berger et al., 2002) framework and they communicate using the FIPA Agent Communication Language (FIPA TC Communication, 2003). The MAS was designed using the Gaia2JADE process (Moraitis and Spanoudakis, 2005). The system's architecture is presented graphically in Figure 2.

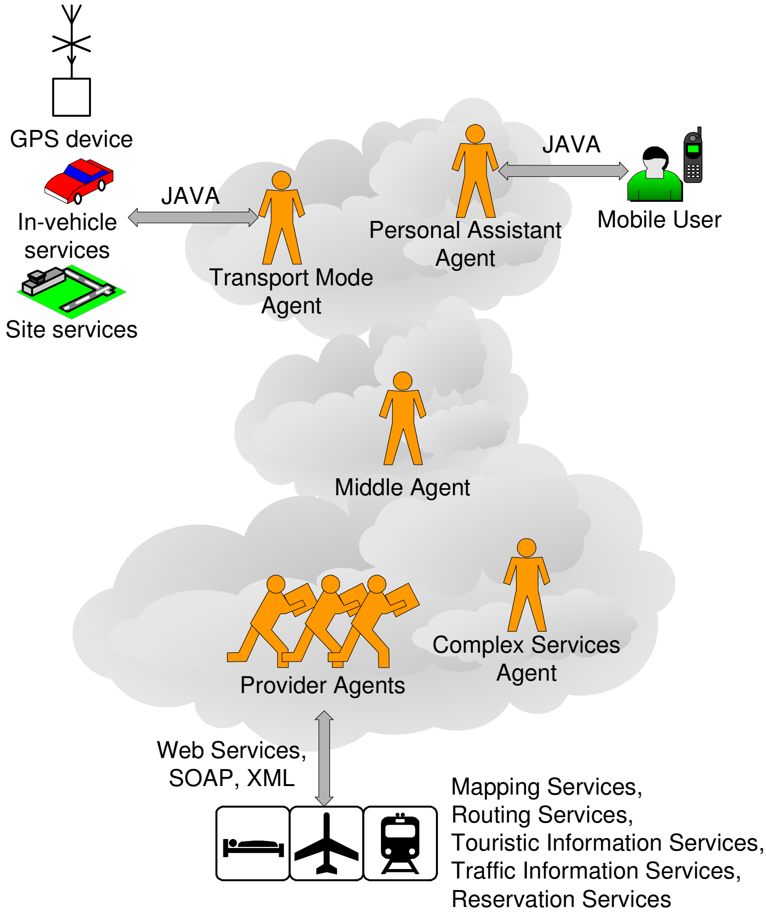

Figure 2: The MAS architecture.

The service network that is created within this project is enabled by the use of middle agents in the form of brokers. The provider agents advertise their services to the brokers and whenever a personal assistant agent requests for a service the broker matches the request to the available advertisements and if he finds a match he forwards the request to the appropriate service provider. When the latter responds with the answer, he forwards it to the personal assistant. Thus, the user's identity is not known to the service provider agent. The user just has to trust the broker and can access through him all available services.

The important issue tackled using this architecture is that the filtering of POIs in every POI search request takes place on the server side. The complex provider agents handle such tasks. They also filter routes in order to provide the user with the best routes on his device. Thus, a part of the user's profile is transferred to the servicing agents along with the request.

The role of the personal assistant agent is to acquire data regarding the user behaviour (POI and route selections) and then supply the complex provider agent with the data needed for the use of the algorithms presented in section 3. Thus the user will only get the filtered data on the nomad device that generally has a slow internet connection (e.g. GPRS) or pays per kilobyte downloaded. If the personal assistant filtered the available data himself then the quality of service would be low (slow and expensive).

The presented architecture provides solutions for the future personal travel assistant (PTA) developments as they have been identified by FIPA (FIPA Architecture Board, 2003). The challenge of agent mobility in a network is addressed (the personal assistant agent delegates the task of filtering huge amounts of data to the complex provider agent by sending parts of the user profile along with the user request).

5 Conclusion

The above-presented algorithm and Multi-Agent system is currently verified with 30 users, in order to define the thresholds of *T(NR)i lim*, *S(NR)i lim* , *(RP)j lim* and $(\frac{RP}{TP})$ *lim*. The optimisation and finalization of the algorithm, both in terms of design and implementation, focusing on its usability and reliability, will be realized through the final pilots of the project, that will take place in a pan-European site, which interconnects 5 urban areas (covering micro - transport terminal, urban and/or interurban levels, depending on the occasion), covering in good balance Northern (Finland), Central (Germany), Southern (Italy, Greece) and Eastern (Hungary) Europe. Users from each pilot site will travel throughout European corridors, following routes that bring them alternatively across other sites and different content. The application scenarios cover all service environments (city, intercity, integrated), all types of modes within complex travel chains (car, bus, tram, metro, train, ship, airplane, airport facilities, touristic information) and all types of users ("average" user, social-recreation traveler, tourist, businessman, commuter). Finally, an intra-site test, having people traveling from one site to another (covering nearly all of them) will be performed, to test the offered services interoperability and roaming models. Thus, during these pilots, the IM@GINE IT integrated system demonstration will be performed.

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