Mobile/Wireless Systems for Infomobility Services, Based on Intelligent Agents Technology

Dr. Evangelos Bekiaris
Hellenic Institute of Transport (HIT),
6th km Charilaou-Thermi Rd., 57001 Thermi, Thessaloniki, Greece,
Tel: +32310 498265, Fax: +32310 498269, E-mail: abek@certh.gr

Nikos Spanoudakis
SINGULAR, Emporiko kentro LIMANI, 43, 26th October str, 54627, Thessaloniki, Greece
E-mail: nspan@si.gr

Dirk Esters, Markus Kauber
PTV Planung Transport Verkehr AG, Stumpfstrasse 1, 76131 Karlsruhe, Germany, E-mail: Dirk.Esters@ptv.de, Markus.Kauber@ptv.de

ABSTRACT

Mobility services is a key area for mobile systems, as de facto the user is not travelling and not near any stationary info-point. Still, current info-mobility applications on mobile systems (such as PDAs and mobile phones) are very limited due both to insufficient technological capabilities and lack of appropriate user friendly interfaces. The technological barriers have been now overcome through GPRS and UMTS technologies, but still the available space in mobile equipment screens is not enough for efficient presentation of complex route maps and much info.

IMAGE project (IST-2000-30047), co-funded by the EU and encompassing 16 partners from 5 European countries, aims at developing an intelligent and geo-referenced info-mobility services, that can provide to the user the info he/she wants at the time he/she needs and according to his/her preferences. Thus, tourist and transport services (route guidance and navigation to museums, hotels restaurants, etc.) are offered through PDAs and mobile phones (using GPRS and GPS for user location). To be able to offer in real time and in a user friendly way these services, the service provider needs to understand in detail the user needs and monitor the service provision.

Thus, a set of Intelligent Agents is developed, such as an Educator Agent, that monitors user actions and self-builds his/her profile, an Event Handling Agent that supports the user if the service is disrupted at any point (i.e. cancellation of service of connection bus, etc.). The relevant Agents family is analysed within the paper. In addition, a number of georeferenced, mobile and wireless infomobility services are realized (namely geocoding, mapping and routing web services), that support modular and personalized use cases. A typical use case of IMAGE system is presented, as well as, the web services supporting such use cases.

The paper explains the concept of the system, briefly presents its architecture and focuses on its user-friendly interface and the mobile units it supports.

Keywords
Intelligent Agents, Infomobility services, Georeferenced services, Navigation, Routing.

1. INTRODUCTION

The evolution of telecommunication technologies and their convergence has considerably altered the consumer's idea of communication: what in the past has been simply acknowledged as a media for voice transmission is now also becoming a mean to transmit data and conduct transactions with remote organisations. This has led to fruitful business opportunities built around the new concept of data service provision & interactive e-commerce through wired PCs and recently through mobile telephony as:

- At the front end, hundreds of millions of users have today access to contemporary means of communication, and the trends indicate that the numbers will further rise, as shown in figure 2.1, while
- At the back end, useful data content is becoming available and organised in electronic way at several sites in the EU and internationally.

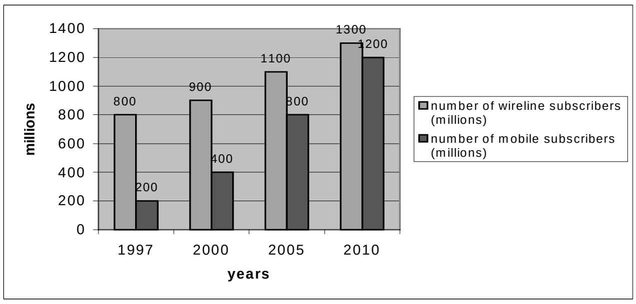


Figure 1: World-wide growth of wireline and mobile subscribers through 2010 [1].

Mobility is one of the key areas for such business development. It is the one aspect of everyday life that: a) involves continuously growing figures, b) is subject to dynamic, unexpected changes of schedules, c) refers to a complex mix of transport networks and modes and d) is related to several other activities and services. However, mobility is not a mean to an end by itself. It is generated by the needs of the individual: personal needs, professional needs, social needs. Hence, mobility information is only a part of the whole picture, which is much more comprehensive when mapping the range of activities (*end products*) at a certain geographic area. Furthermore, the advantages of mixing localisation and navigation applications with plain transport information are enhancing the robustness of the final service.

Many relevant *services* (of various levels of sophistication) have been launched to the market, for example public transport timetables, traffic information, navigation tools and/or service indexes with geo-reference, such as hotel indexes. Some of the services have failed while others have just moderate success. Why the poor market success, if indeed the previous business assumptions are correct? Is it because the application development is expensive, or because the end user is not willing to pay (at least a marginal fee)? Is it because the developed services are not satisfying the global customer requirements or they do not offer sufficient coverage and/or usability? The IMAGE consortium believes it is a mixture of these reasons and comes with a new technical and business solution, which will be thoroughly checked and verified within the project framework.

IMAGE designs and develops an open and modular service platform, which will act as the central point transparently co-ordinating both end users data (*user request*) and service provider data (*provider response*).

The service platform consists of:

- An *intelligent module* that "intelligently" manages, processes and monitors end users' requests and individual profiles/preferences for geo-referenced and time-dependent servicing.
- A *data management module* that interfaces with external entities databases in order to deliver the required data.
- A *GIS platform* that provides reference of both end-users' and service providers incoming data into geographic co-ordinates.
- The identified integral IMAGE-responsibility *services*:
  - Localisation service, to acquire the position of the end user in the geographic environment.
  - Navigation service, to guide the end user to the required activity (end product) so as to satisfy his/her need.
  - E-commerce service, to delegate and link end user to external e-commerce services.

2. IMAGE USE CASES

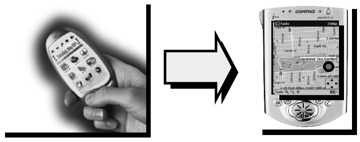
There are 5 basic needs identified for the end user:

- To determine current user mode.
- To obtain information about the 'Other Service' (this is sometimes called a Point of Interest).
- To arrange a trip that will enable him to obtain the 'Other Service' (route planning).
- To arrange for the 'Other Service' to be available (e.g. through booking and/or payment).
- To make the journey (dynamic support and information about events).

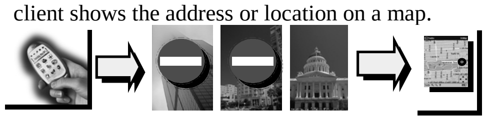
The first of these allows the inclusion of the user's need to change profile. The remaining lead to the required services for satisfaction of end user requirements. The identified basic needs can be interpreted into the following basic functions (not necessarily in this order). The hardware shown is just an example:

1. The user sets or chooses his/her profile

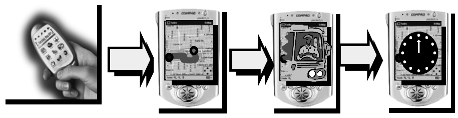
2. The user asks: "Where am I ?" The IMAGE client responds by giving the address or the location on a map.



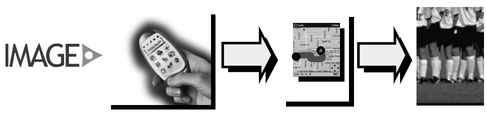
3. The user asks:" Where is the address/ happening/place" or "What is available?" The IMAGE client responds with a list of possible options. Then user chooses one option. The IMAGE client shows the address or location on a map.



4. The user asks: "How do I get there ?" The IMAGE client shows the route map and timetables for suitable transport.



5. The user does not have to ask: The IMAGE client suggests and sells a ticket for the event and corresponding transportation to the event location.



6. The user does not have to ask: The IMAGE client informs about an event along the chosen route that matches the user's personal profile.

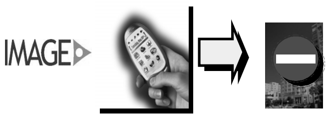


Figure 2: IMAGE Use cases concept.

The figure above illustrates the basic functions listed below:

- Setting of personal profile.
- Question about the location, where the IMAGE client gives to the user his/her address, showing it also on the map.
- Question about address/happening/place or availability, where the IMAGE client responds and provides a list of possible options. The user selects the desired/ right one. The IMAGE client shows the address/map.
- Question about route guidance, where the IMAGE client shows the route map and timetable alternatives for the suitable transportation (mode).
- The IMAGE client suggests and if accepted, sells the user a ticket for the event/transportation and shows also other events nearby that match the personal profile of the user.
- The IMAGE client informs the user for an “event”: either a transport or event recognised on “accepted” route (monitoring the trip), or activated by user location, or a new event, recognised to be of interest to the user based on his/her profile (for example, a new show matching user’s preference is on).

3. IMAGE INFOMOBILITY SERVICES

Within IMAGE, mobile and wireless infomobility services are implemented as SOAP/XML based Web services according to the W3C standard [2]. With this technology it is possible to switch from rather inflexible XML interfaces to flexible, and, especially at the client side, easy to implement services. The possibility for any interested party to easily connect to high-end geo-services was one of the major reasons to follow this progressive idea.

The obvious tendency for integrating services and the trend to co-operations between content, service, and network providers will require the implementation of intelligent and open interfaces as it is increasingly realised in XML (Extensible Markup Language) and SOAP (Simple Object Access Protocol) technology. The latter one is known these days mostly because it is already one step ahead of pure XML and promising for the task of inter-connecting the services and content of different market players with easy means. The so-called “Web services” are based on a client – server architecture which is supported by both, Sun (Java) and Microsoft (.NET). Any party that wants to make use of the Web services of another company just has to implement the client-side part in it’s system architecture by adopting the functions and data structure that is described in the automatically generated Web Services Description Language (WSDL) file. Thus, one could assume, that Web services should also support mobile end devices such as PDA’s directly. In fact, Microsoft has announced to introduce a development kit for mobile devices during this year. The current market developments, however, show that the two competitors more and more follow different road maps. One the one hand there are Sun and Oracle, which support the W3C efforts for a standard, and on the other hand there are Microsoft, IBM and SAP who try promote their own developments (Business Process Execution Language for Web Services, BPEL4WS).

IMAGE georeferenced module consists of three different Web services. They interface various IMAGE modules, such as the Data Management Module, the Intelligent Module or the User Interface. Theoretically one set of Web services would be sufficient to cover all tasks in IMAGE related to mapping, routing and geocoding, but, by taking two geographically separated test beds and system performance into account, it was decided to implement them separately for Tampere in Finland and Torino on Italy (two test sites). The goal was, that the user will not realise from which of the two providers the maps he/she is requesting are retrieved. In such a way, the IMAGE system is proving the advantages of Web services for the inter-linking of different and distributed Internet data sources.

The overall layout of the mobile services and the key modules of IMAGE system are highlighted bellow and explained within the paper.

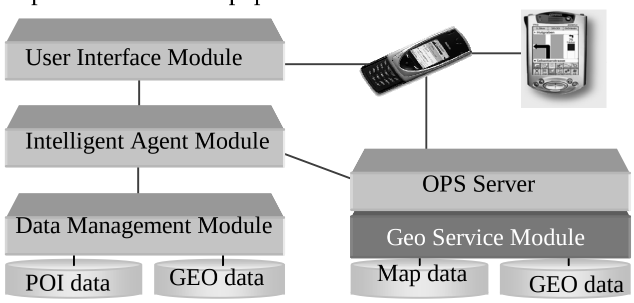


Figure 3: Georeferenced services within the IMAGE Architecture.

The three different services are briefly described below.

3.1 The Geocoding Web Service

The service allows two types of geocoding, normal geocoding and reverse-geocoding. With normal geocoding the user enters an address and gets his/her position geocoded in either WGS84 GeoDecimal, WGS84 GeoMinSec, Mercator or SuperConform format. For the IMAGE project WGS84 GeoDecimal was selected in order to provide a unified standard for all services. If there is a misspelling in the address, such as wrong street names, the user gets a list with possible address matches. Each address in the list has already it’s coordinates, thus no second geocoding request is necessary. Reverse-Geocoding instead, allows the user to get an postal address next to a given coordinate.

3.2 The Mapping Web Service

The mapping service in the IMAGE project visualises the requests sent to the routing and geocoding service. The maps can be either coded in JPG, GIF or PNG format and are stored on a special server to which the User Interface can sent an http call in order to collect the map.

In the map server dynamic content can be displayed by using so called „Dynamic Address Layers“. Address layers are layers that contain geographical information that can be visualised in a map, but which is separated from the original basic map, e.g. stored in a database. They must be categorised, for example HOTELS, WOODLAND, WATER and EVENTS. POI (Points Of Interest) can also be stored in address layers, thus making them very easy to handle with professional database tools. Each category represents one layer, but the layers are not fixed. It is easily possible to add and delete new/old layers. The advantage of using dynamic address layers is, that there is no interaction between the basic map geometry and the dynamic content during runtime.

3.3 The Routing Web Service

Different types of road networks are necessary in order to do routing either for cars, pedestrians or inter-modal transport. Thus the road networks (road geometries) that are the basis for the routing server have been prepared in different ways in order to serve the following routing options: FASTES, SHORTEST and CHEAPEST. Various types of attributes have been attached to the single road geometries.

The final output of the Web service for Routing, or the routing application itself, is not a route on a map, but a route list. The route list comprises all coordinates (way points) that are necessary to draw the route on a map. The higher level points, such as intersections, are presented to the users in form of a list together with turn-by-turn driving information. For each turning point the routing service provides additionally a very small map (minimap), which visualises the directions on the intersection graphically.

4. IMAGE INTELLIGENT MODULE

Intelligent module (IM) is the “heart” of the Image Agent/System. It integrates existing georeference services (i.e. routing, mapping, proximity search, geo-coding, GPS tracking), content providing services (lists of points of interest, e.g. restaurants, hotels, etc), it introduces the personalization feature and self-learning ability, and, finally, the interoperability feature, in order to provide the modern mobile user (be he/SHE commuter, business traveler or tourist) with personalized location-based global M-services.

4.1 Architecture

The intelligent module was developed in an agent-oriented manner. The Gaia methodology was used during the analysis and design phase [3]. As a development framework we used JADE [4]. An original roadmap for engineering JADE agents using the Gaia methodology was proposed during the IM development phase [5]. The system design is presented in the same paper.

The IMAGE Intelligent Module is composed of several types of agents through a layered approach. These agent types and their interaction with one another and with the rest of the IMAGE modules are presented in Figure 4. The interaction among agents is accomplished through ACL messages with standard FIPA performatives [6]. All agent have s*ocial ability*, i.e. they maintain an acquaintances structure that contains white and yellow page information about other agent-contacts.

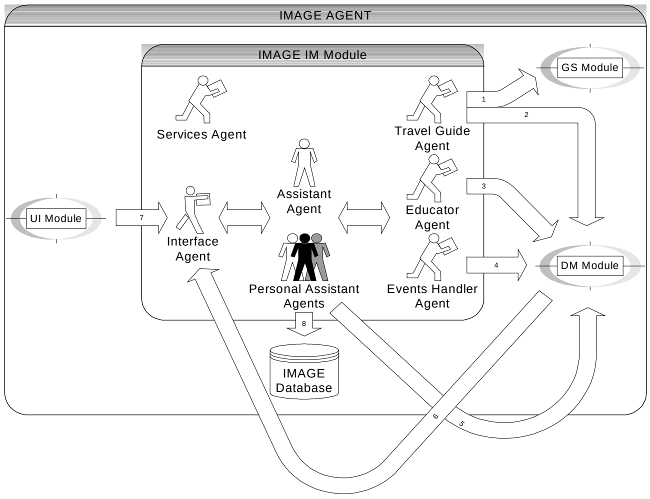


Figure 4: IMAGE Intelligent Agents Architecture.

The IMAGE system is designed to serve mainly registered users, although it is capable of providing services with limited functionality to unregistered users with no profile. The service to guest users is the task of the assistant agent. Each registered user has his/her own personalized assistant agent that serves the user needs regardless of the user login status. The user personal data, his/her preferred choices of routes, POIs, and other habitual patterns are always at the disposal of the personalized assistant, who is responsible of the maintenance of these data to the IMAGE database. Service adaptation to user habits is achieved by hour of the day dependent profile management and continuous refinement of user selected POI types whenever the user requests to view specific POI types around him/her. Refinement is based on a heuristic learning algorithm that assigns weights to user selected POI types and their specializations (for example a “Chinese restaurant” POI type is a specialization of “restaurant” POI type). So, the user doesn’t see his/her profile changing but the service is continuously adapted to his/her needs. It is considered that one instance of the second layer agents (i.e. travel guide, educator and events handler) is sufficient for the seamless operation and overall performance of each platform. These agents have the knowledge of the various communication mechanisms that are necessary to interact with the Data Management and Georeference modules but they do not have any knowledge about the user and his/her needs.

4.2 Functionality of the Intelligent Module

An illustrative scenario is presented in the form of sequence diagram in Figure 5. It is a snapshot from the

JADE platform provided sniffer agent, who is used for inter-agent messages exchange monitoring by the JADE framework. The monitored agents, that participated in the presented sequence, are (from left to right) an interface agent (Interface), a personalised assistant agent (Personalised Assistant), an assistant agent (Assistant), two travel guide agents and an educator.

The interface agent accepts requests from the (User Interface) UI through TCP/IP sockets and XML messages. It evaluates the request and if it belongs to a registered user forwards it to the relevant personalised assistant, while if it is a request from a guest forwards it to the assistant agent, transforming them from XML to ACL messages. The "Requests" with identification number "9047" refer to a user login request, followed by a request to plan a trip and finally by a logout request. The interface agent forwards all these messages to the Personalized Assistant with whom the requesting user is registered. The personalized assistant replies with "Inform" messages that are encoded to XML and sent back to the UI.

The "Requests" with identification number "9048" and "9049" refer to requests from guests. They are also sent a reply as soon as the inform message from the assistant agent arrives to the interface.

It is worth observing that the assistant agent types use the educator and travel guide agents services in order to form a valid response to the user. That is why we claim that this module offers complex services. It uses filtering and inference mechanisms in order to provide the user with a high-level service using simple services (i.e. routing, mapping, proximity search, geo-coding, GPS tracking).

Moreover, the fact that each agent is executed in its own thread provides a parallelism of tasks that can be observed in the sequence, thus serving many users in the minimum possible time. The assistant agent for example serves both guest users requests in parallel and this doesn't cost to response time because the real time cost is the invocation of the web services that provide the generic services by the travel guide and educator agent types.

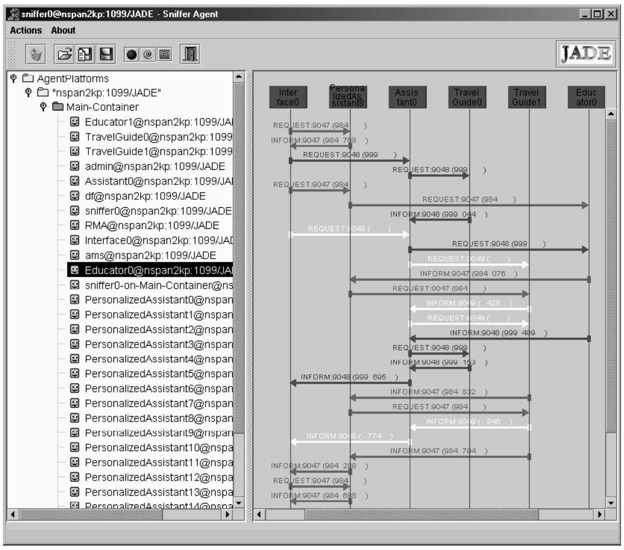


Figure 5: A snapshot of the System in operation.

5. CONCLUSIONS

IMAGE combines mobile and wireless, web-based and georeferenced services with Intelligent Agents technology in order to offer modular and personalized infomobility services to the user. Thus, the service adapts itself to the location, the preferences and the needs of the user.

These integrated services have been currently installed in the cities of Tampere and Turin and will be evaluated by roughly 50 users in each site, encompassing also specific user cohorts, such as tourists, elderly and disabled. The a priori user acceptance of these services, monitored in the two tests sites, as well as in Newcastle in UK, has been very high. The IMAGE Consortium is looking forward to the final evaluation results in order to verify the high potential end viability of this new and innovative service concept, which may be summarized as:
"seamless and personalized service everywhere, anytime and for anyone".

6. REFERENCES

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