INTEGRA SYSTEM

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Abstract: The current work deals with the scenario of growing population in the cities and the associated sustainable mobility problems. To address this problem it is developed an system called INTEGRA for a mobile device, based on the integration from different data sources such as multi-modal public transportation systems, car and bike sharing. This system is able to show and give guidance towards points of interests (POI) and promote a social collaborative network for the share of notations towards POI classification. This work is a contribution for the European Project START, where we propose the Integra System. This system's goal is to make travel easy and sustainable improving information systems integration. This goal is shared by transport operators and authorities associated to the Integra registered brand, promoted by the START consortium, that is already prepared for UK, France, Spain and Portugal.

1. INTRODUCTION

There is difficulty in obtaining information about traveling to, from and within a region, even in the same city, due to the diversity of transportation operators. Most of these operators have their own system, so that they work and plan the routes and schedules independently of nearby operators. Also public transport systems differ from region to region. It is therefore understandable that when reaching a destination, even for the most traveled user, it becomes difficult to use local public transport due to poor organization of information, and especially due to language barriers, for those who do not speak the native language of the country. In this context, is denoted the scarcity of appropriate information systems to assist travelers in the region, including providing practical information, essential to understand the operation of the means of transportation.

The availability of the Internet and the current development of Information and Communication Technologies (ICT), became the best way to disseminate information, inspiring the development of strategies to support tourism and culture. Additionally, the mobile guides are increasingly seen as an asset to offer an experience more appealing of visitation and interpretation to natural parks or historic sights. Technological advances allow higher processing in smaller devices, making possible the use of technologies such as GPS and Wi-Fi. In addition, the popularity of social networks, like Facebook, showed the willingness of users to share their experiences and be part of communities with similar interests.

Part of this research work was used in ISEL participation on the Seamless Travel across the Atlantic Regions using sustainable Transport (START) project. START Project is a European Commission's Transnational Territorial Cooperation Programme with 14 partners from the UK, France, Spain and Portugal. The main mission is the establishing of a transnational network of regional & local authorities to promote enhanced accessibility, giving tools to make easy to travel to, from, and around the Atlantic regions, using environmentally friendly, collective modes of transport, greater interconnectivity between transport systems, clearer information within regional gateways, airport hubs ports and rail interchanges. For more information see [http://www.start-project.eu].

Main contribution of ISEL on this project was the data integration of multiple transportation sources [Costa, 2011], a system to support user on public transportation query data and a Car and Bike sharing System [Xavier, 2011]. The INTEGRA system should allow the interrogation of multiple sources of information through a single interface. The questions and answers to them should reflect a single data model. The existence of a single common data model takes the client applications with the difficult task of dealing with various technologies and their relational schemas different. Different public transportation systems can be added with total transparently to the end user. From START project different public transportation data and data base schemas were tested. Also this integration allows the creation of mobile systems oriented for tourisms purposes, other main goal of START project, where "low budget tourism" can be guided, to reach POI (Points of Interest) by public transportation, look and reserve parking slots.

2. PUBLIC TRANSPORTATION INFORMATION INTEGRATION

In Figure 1 is illustrated the public transportation different sources data integration approach, where is possible data information integration from different operators of public transportation. This application output is a user Mobile Device, or Web Application SITP, that is described in Section 3. The data integration is based on a domain ontology (Ontology for Public Transportation - OPT) [Ferreira, 2011], a wrapper that performs the mapping between different public transportation data base models and a mediator. If the public transportation operator data base is constructed under OPT the wrapper and the mapping definition are not needed. Wrapper is developed at each operator side based on operator information source and is a common interface for data access. In Figure 2 is presented the wrapper solution based on [Bizer, 2009]. D2RQ is a declarative language to describe mappings between relational database schemata and OWL/RDFS ontologies. The D2RQ Platform uses these mapping to enable applications to access a Resource Description Framework (RDF) view on a non-RDF database through the Jena and Sesame APIs, as well as over the Web via the SPARQL Protocol and as Linked Data.

SGBD Schema Publication is the mapping process between local data base and the vocabulary of the ontology (OPT) using R2RQ language. The Process is divided in the following steps: (1) entity definition; (2) adding of proprietaries to the entities; (3) connection of entities; and (4) definition of conditions and aggregations (when necessary).

Mediator is based on MediaSpaces Mapping Framework, where it is possible to perform SPARQL queries based on OPT.

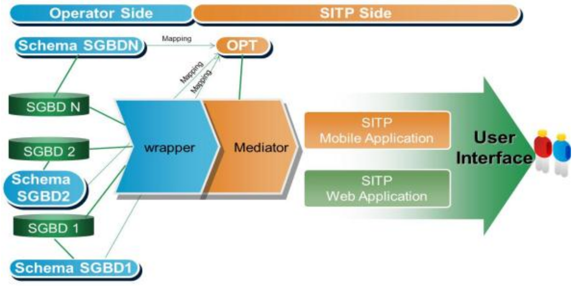

Figure 1: Different sources of public transportation data integration approach

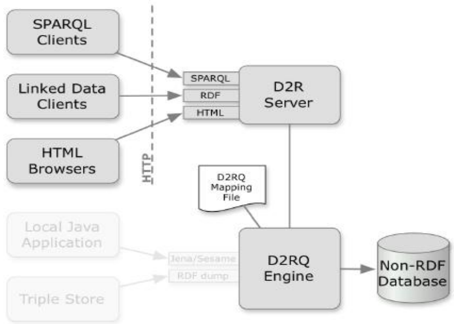

Figure 2: Platform D2RQ used at wrapper components

3. SITP APPLICATION

SITP is the application to handle public transportation information in a mobile or web application and is part of Integra system. In Figure 3, is illustrated a typical client operation from the client side: search for stops, search information of public transportation for a certain path, get price, schedules and best itineraries path options. From the operator are showed the registration and the registration of DB schema.

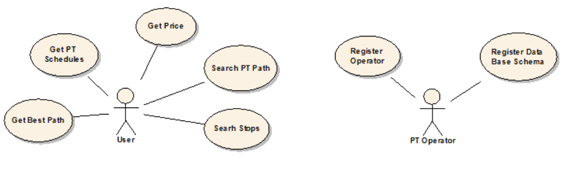

Figure 3: Use case for SITP application

Two Web applications were developed:

- SITP, to support queries from users;
- SITP, for the management of information by the public transportation operators.

These applications were implemented in ASP.NET MVC platform. For more details, see [Domingues, 2010].

The SITP was implemented to allow the user to search for routes, stops, query times and fares. Figure 4 illustrates the application menu to support these functionalities.

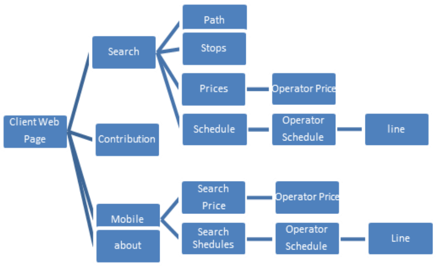

Figure 4: SITP - Web Client Application Menu

The developed application has the basic structure of a Master Page with an application menu. The menu implemented allows navigation of the site as intended, with Multi-Language support and a link to access mobile devices (see Figure 4 and Figure 5).

Figure 5: SITP - available menu for users

Figure 6: SITP - available menu for public transportation operators

In Figure 7, we show a SITP search for near public transportation (stops), using a pre-defined radius from current user position. Taking into account current time the SIPT indicates also close public transportation to arrive on selected stops.

Figure 7: Search result of a user query for a PT stop in a radius of 50m from his current position in Lisbon (Cais do Sodré, description in Portuguese Language)

In Figure 8, we show a case of getting public transportation prices for the desired journey for the Portuguese company CP (a railway company).

Figure 8: Search result of a user price query for CP public transportation operator (description in Portuguese Language)

4. CAR SHARING SYSTEM

Car sharing systems balance between private and public modes of transportation. They allow individuals to use a car when needed without having to buy one for their exclusive purpose. This, obviously, comes with some inconveniences, such as having to reserve the car for a predefined period, having to walk to the nearest parking lot, or needing to select another mode of transportation if no car is available. However, it also has many advantages because it gives access to a private, flexible mode of transportation, without having the entire burden that comes with it. Hence, it is not that surprising to see that car-sharing systems are becoming more and more popular and that people are willing to engage in this new mode of transportation.

Car sharing is not a new transportation mode. Years ago, when cars were luxurious goods, households were uniting to buy one. Its ownership and use were shared. It was for these households the only way to have access to an automobile. Nowadays, car sharing responds to new needs and is provided in an organized system. People want to benefit from the car's flexibility without supporting all its inherent costs: insurance, parking, maintenance, etc. Users are also attracted to car sharing because of its good environmental image [Steininger, 1996]. Figure 9 shows eleven car sharing parking locations in Lisbon, what represents a reasonable implementation of car sharing initiative. Car sharing services are managed by companies, like short term car rentals. Car Sharing Organizations (CSO) usually manages a fleet of vehicles dispatched in several predetermined parking lots. Members have access to any vehicle at any time, given that they have made a reservation in advance. Car keys are usually located in a safe-deposit box located near the parking lot. Users can keep the vehicle during a fixed period of time that can vary from one hour to several days. At the end of the rental period, the vehicle has to be returned to a parking lot (usually the one where the car was taken). Traveled distances and rental durations are recorded and used for the billing of every user (fees depend on the total duration and mileage) [Barth, 2001].

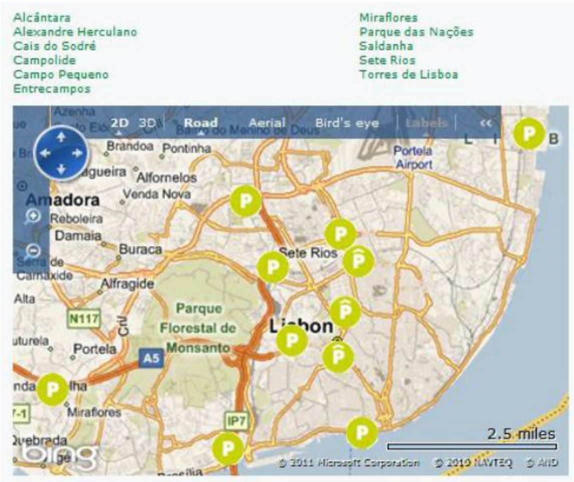

Figure 9: Car Sharing parking places available in Lisbon, status Jully 2011

Some studies have been conducted to estimate the potential of car sharing in urban transportation and changes in transportation behavior when a car sharing service is available [Lee, 1998], [Cervero, 2002] and [Steininger, 1996]. Cervero et al. [Cervero, 2002] state that this mode could attract users towards individual car ownership for the San Francisco area. Other authors indicate that, on contrary, CSO helps to decrease car ownership because some users leave their individual car to enter the system. Positive impacts of car sharing on travel demand and on greenhouse gases (GHG) emissions were also reported by Morency [Morency, 2007]. Most of these studies are based on user surveys and can hardly characterized long run use of car sharing. Barth et al. demonstrated the potentialities of using individual data collected in a multi-station shared vehicle system [Barth, 2001]. On a pure economic basis, CSO can be both viable and profitable [Wright, 2001]. Several systems are running through the world, especially in Europe (UK, Germany, Italy, Netherlands), in Canada (Toronto, Montreal, Quebec City) and in the United States (Seattle, Portland, San Francisco area).

The proposed system is similar to the reservation slots of a public charging station and it was developed in a Final Year Project at ISEL [Xavier, 2011]. Main system functionalities are described in Figure 10.

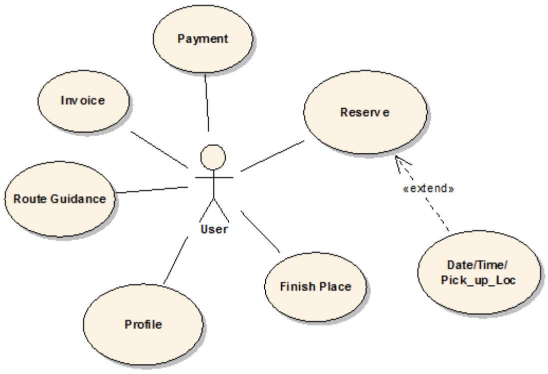

Figure 10: Use case for car sharing system

5. BIKE SHARING SYSTEM

Bike share is an emerging urban transportation concept based on collective paid use of a distributed supply of public bicycles. It is similar in function and programming to car sharing initiatives that have been very successful in several places. In general, bike sharing consists of strategically distributed "stations" containing ten to twenty bikes on average, with a centralized payment/control kiosk. Customers—who range from one-time users to long term subscribers, "unlock" a bicycle with a credit card or smartcard, then ride to any other station in the city where they can deposit the bike, concluding their trip. Bike share fills a number of key "niches" in the urban travel market and is particularly useful for relatively short-range travel beyond the length of comfortable walking distance. Its key advantage is that it gives virtually everyone access to what in the past had largely been viewed as a specialized form of urban transport, promising increased use of bikes for short-distance travel, helping to decrease pressure on traffic and transit systems.

Main functionalities of the proposed Bike Sharing system are defined in Figure 11 and for more details see master project at ISEL [Costa, 2010].

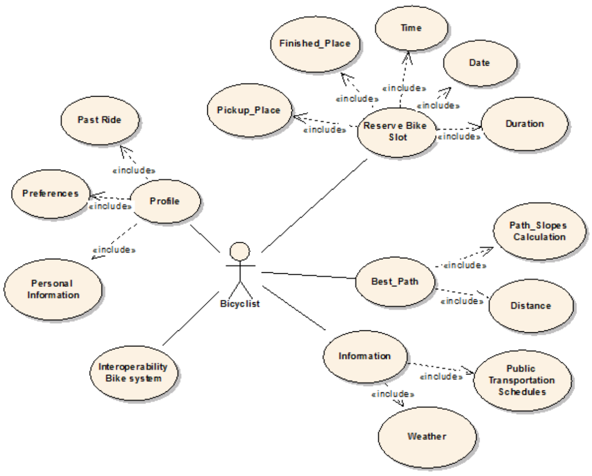

Figure 11: Main Bike Sharing system functionalities

5.1 Weather

The extremes of weather affect bicycling more so than any other practical mode of transportation, on both short-term (day-by-day) basis and longer-term trends. Extreme heat, extreme cold, and heavy rainfall are the top weather phenomena leading to decreased numbers of cycling trips. User Profile can be used to define if the user wants to use a bike under certain weather conditions (rain, too cold or hot).

5.2 Topography

Like weather, topography has an impact on the willingness of people to use bicycles, although in this case it is often limited to certain trip patterns rather than affecting system usage as a whole. This is apparent in the evaluated European bike share cities, which regularly exhibit shortages of bicycles at stations at the tops of hills or steep gradients, suggesting that many users are riding downhill but not back upwards. The study of the slope is particularly important for cyclists and pedestrians. For the slope Google API allows the following operations: (1) get the altitude of a particular point; (2) get the altitude of n points in a straight line path, where n is the number of samples required; and (3) get the altitude of a set of points.

Figure 12 illustrates an invocation of Web service for calculating the profile of a set of points.

Figure 12: Google Web Service Elevation

Figure 13 presents an application of this service, where appears the bike path and the elevation in meters.

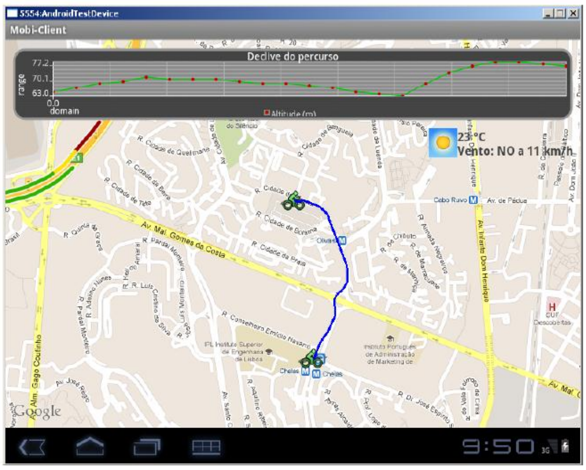

Figure 13: Example of a bike path with the elevation in meters (top of figure)

6. DATA INTEGRATION

External data of Public transportation, Parking Places availability and location and points of interest (POI) are merged with public transportation, car and bike sharing information. Traffic in real time information is available from road concessionaries, but outside these organizations, the access to this information is most of times denied. We propose an XML file is an approach of future data integration from different source providers.

6.1 Looking POI with Guidance

The user of Integra System can: (1) get directions; (2) Points of Interest (POI); (3) get recommendations on his journey using public transportation.

After user login (authentication), there is a menu where the driver selects which operation he wants to make; this is organized as Figure 14 (left side). If he wants to know possible interest places, from Recommendations tab Places, he has the screen shown in Figure 14 (right side). The user defines which region the system should consider introducing the geographic center and radius, which can be obtained using GPS or an address. Pressing the button Get recommendations are obtained, and in this case the user wants to know Points of Interest (POI) near Seixal, in Portugal, considering a radius of 2 km. At the bottom of the screen the user will find the recommendations identified by the name and address of the location of interest. The user can get more information about the location of interest selected by pressing the Info option from the menu.

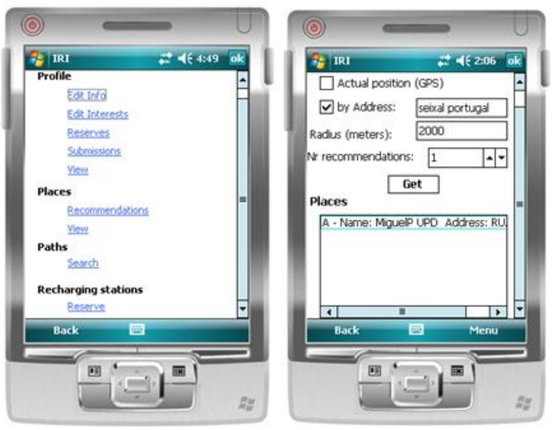

Figure 14: Main application screen and search for POI (Points of Interest)

Figure 15 shows the screens to identify a POI. Information from a point of interest is constituted by its name, address, latitude, longitude, brief description, associated categories, hours of operation and a display picture. In the user classification menu option, the user can rate the point of interest in order to help future recommendations to himself and to other users.

The screen lets you annotate/classify the site of interest, with a degree of satisfaction, such as "Good." The following Figure 16 (left side) represents the screen. If the user wants help geographically he can access it from Map menu to display the selected site of interest, as is visible in the Figure 16 (right side). The site contains an identifier of interest (in this case is A), and in this screen the user has the ability to navigate the map, as well as zoom in and zoom out. In the menu he can change the map type view (Hybrid, Roadmap, and Satellite).

Figure 15: Screen for POI (Points of Interest)

Figure 16: Visualization and classification of POI (Points

Figure 17: Get POI (Points of Interest) and get directions

of Interest)

If he does not like the recommendations generated, he can always get all the sites in a given area by accessing the item in the Places tab View. This screen is similar to the screen that lets the user get recommendations of sights, but this one shows all the sites in a given region with the possibility of filtering according to the categories of places of interest, as shown in Figure 17 (left side). After the user selects possible sites of interest to visit during the holidays, he needs to know which route to use in order to visit this place of interest. The screen is in the following Figure 17 (right side).

6.2 Public transportation Data Integration

Information on public transport is available to the system in the form of an XML file that contains position information of the geographic locations of the transports stops (result of data integration process). The recommendation system submits the items collection of items for the *PublicTransportService* that identifies each item to its proximity to an interface with public transport. If yes, the property *nearPublicTransport* item is placed with the value of one. The connection to an information system is made by public transport component *PublicTransportAdapte*r, see [Ferreira, 2011a].

6.3 Parking Places

The booking parking places is based on a system for management of reserves (Sistema para Gestão de Reservas - SGR), that allows driver's mobile devices to communicate and performs reservations. To communicate with the SGR should be used a technology that allows synchronous communication. The Integra system is prepared to communicate with the SGR with a *WebService*. The SGR responds to mobile device communication response with a reservation confirmation, or with a warning indicating the unavailability parking slots. One of the issues that arise when proposing an SGR is the possibility of drivers failed to attend on time (or even did not show) to a reserve performed. The SGR must implement mechanisms to minimize the impact of slots are being reserved, and then run out by failure of the driver. One possible solution is to implement a scoring system, which penalizes drivers with one point in their record when they fail to reserve a charging slot. When the driver reaches three points, equivalent to three failures, the driver has to go to an operator and try to reactivate his/her access to the SGR.

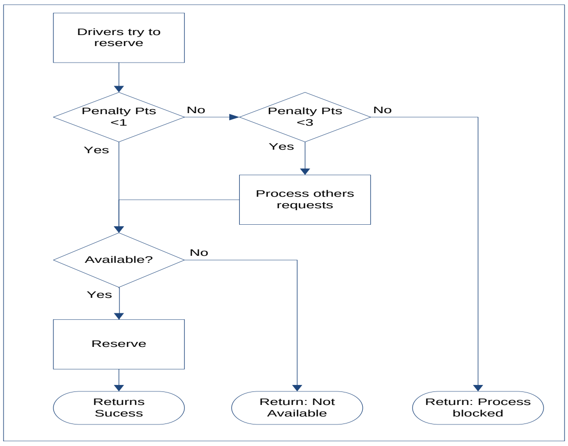

Figure 18: SGR penalty points to avoid user reservation failures

The diagram in Figure 18 illustrates how the SGR can be implemented with a system of penalty points. The information is centralized in the SGR, communicating with all operators, which also allows the exchange of information on penalty points, making the system more efficient. The SGR is prepared to follow a business model that is implemented with a slot reversion, failures penalties and a waiting of reservations of 5 minutes (administrator configurable time). The same approach and software module is used for parking places reservation.

7. TRANSPORTATION BEST ROUTE ADVICE

Integra System, can give the best advice in terms of a diversity of options: public transportation from several operators, car and bike sharing system, see Figure 19.The system can be configured to give the faster option to go from point A to B. This could imply a mixture of options. Also best advice could be the cheapest option.

All public transportation data (to the Lisbon area) were exported to a graph, where the arc length is defined by the time that it takes to go from one node arc to the other. The same procedure is applied for car sharing, POI and bike sharing systems. With all information in a graph, the best path algorithm, described in [Ferreira, 2011a], can be applied. The big issue is the matrix size that could increase a lot with a large diversity of options, and could generate computer memory problems on handling this matrix. Some heuristics were defined to speed up this process. The arc weight can be constructed from a diversity of options, time, price and $C0_2$ emissions.

Next Sections explores this issue from a perspective of a green policy.

Figure 19: Integra Transportation best advice

Also this integrated approach of a diversity of systems, with geographic information, could be important for transportation planners or to political decisions regarding transportation. The main idea is to adapt arc weight to a combination of items that could reflect an environment policy. Arc node reflects time, price and CO_2 emission price and a good investigation topic is to find the best combination between time, price and CO_2 emissions price, in order to define the 'best' weight of arc path. This weight could also include a parameter function of city traffic conditions (overload paths should be more penalized). The system has potential to work and deal with different source diversity. This idea is materialized in a final year project at ISEL [Marques, 2011]. Different approaches can be integrated in arc weight calculation: time, price, and a weight related with CO_2 emissions.

8. CONCLUSIONS

The focus on this work is aligned with the "Integra Concept" [http://www.start-project.eu/en/Integra.aspx], whose aim is to provide a single brand that links together and provides information on the different public transport operations across the Atlantic regions. So, the system allows the query of multiple information sources through a unique interface. The queries and answers to them should reflect a single data model. The existence of this common data model takes the software applications with the difficult task of dealing with various technologies and their relational schemas. Different public transportation systems can be added from the end user point of view. Also, this integration allows the creation of mobile systems oriented for tourism purposes. Another main goal of Integra is to provide guidance to "low budget tourism", helping tourists to reach POI (Points of Interest) by public transportation.

Integra System is based on a new approach the "cooperative transportation infrastructure integration", by providing the driver with a collaborative holistic approach of different public transportation infrastructure sources that can be combined with real traffic information (not described in this work, see [Ferreira, 2011]), parking places, to support the driver decision-making process or motive the usage of Public transportation.

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