Cooperative Transportation Infrastructure

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Abstract—This paper provides an overview of a Cooperative transportation infrastructure, by providing the driver with a collaborative holistic approach of different public transportation infrastructure sources, that can be combined with real traffic information, parking places and charging slots and current driver position, to support the driver decision making process.

Keywords—Data integration, Public Transportation, Route planner.

I. 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 transportation 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 modes 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 13 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].

One of the main contributions of ISEL on this project was the data integration of multiple transportation sources [1], and a system to support user on public transportation query data. The 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 transparency to the end user. From START project different transport data and database schemas were tested. Also this integration allows the creation of mobile systems oriented for tourism purposes, other main goal of START project, where tourists can be guided, to reach POI (Points of Interest) by public transportation.

II. PUBLIC TRANSPORT INFORMATION INTEGRATION

Public transport information integration is one specific area, for which there is still lack of EU level data integration among different public transportation organisms. The European Commission has sponsored a series of recent projects which have succeeded in moving forward the State of the Art in the provision of multi modal traveler information. Each project was built on the foundations of the projects before them, which include:

- ITISS (INTERREG IIIIB) which developed the provision of real time information to travelers on the move through mobile devices (2003-7);
- SIMBA 2 (FP7) sought to increase road transport research cooperation between Europe and the emerging markets of Brazil, China, India, Russia and South Africa by
establishing a network of stakeholders in the field of Intelligent Transport Systems (ITS);

- eMOTION (FP6) was a study to investigate, specify and assess multi-modal, on-trip Traffic and Travel Information Services for European travellers (2006-8);
- WISETRIP (FP7-SST) developed a platform for the provision of public transport multi modal travel information between EU and Chinese partners (2008-10);
- OPTI-TRANS (FP7) developed a mobile platform for travellers to plan their journeys using public and private transport (2009-10);
- IN-TIME (ICT-PSP) focuses on the delivery of multimodal Real Time Traffic and Travel Information services to European travellers (2009-11);
- START (INTERREG IVB) which developed a trans-European information portal to enable cities/regions to provide multi-lingual information to travelers, perform simple route planning from region to region and access detailed planning tools and PT operator's data (2009-2013).

This Cooperative platform is not focused on the resolution of a complex process that is the data integration for multimodal planning across Europe, but to determine the value that can be reached with the availability of this information and how this can be used efficiently to complement the journey performed with a FEV. In the UK, a national integrated travel information provider is provided by Transport Direct (www.transportdirect.info), a subsection within the Department for Transport. This site has provided door-to-door journey planning across all public transport modes, private car and some scheduled UK domestic flights since 2004. Recently a number of UK transport authorities have ‘opened up’ their databases and web services for free access so that third parties can develop website and mobile phone applications. This has resulted in a significant step in innovation though has also seen gaps in service provision where demand, technical knowledge and old data have caused problems. In the UK pilot this information will be used. In the case of Portugal and Spain local access to relevant transportation will be negotiated and suitable data prepared for the purpose of reaching the project’s objectives.

Beyond the public sector and private transport operators the main commercial provider of integrated transport information at a global level is Google through its Google Transit service [www.google.com/transit]. This service currently takes data feeds from a number of municipalities and transport agencies across the world though it is fairly patchy in its coverage. This service has expanded the potential audience for travel information but has a number of potential issues which cause concern to the industry:

- To date the service has been modeled on the operations of US transit agencies which has resulted in the data structures and information provision being fairly simplistic and remains about ten years behind the European industry state of the art;

- The service is based on Google data management of imported data which means the data can fall out of date if not reprocessed on a regular basis;
- The commercial nature of the business means that some transport organisations refuse or are reluctant to share their data with the Google Transit service;
- The long term future of the service is not clear as there is no published road map and as a commercial entity could be withdrawn at short notice;
- There are other services being offered on similar lines to the Google Transit system such as Bing (Microsoft) and HopStop. These services fall short of the ambition set by the Commission in this call though they do succeed to some extent in providing a simplistic form of aggregated traveler information for the mass market.

Additionally the EU ITS Directive 2010 requires member states to deliver a number of systems as per the ITS Action Plan. These include provision of Multi Modal Traveler Information Systems by 2015.

III. DATA EXCHANGE STANDARDS

The study of benchmarks leads to awareness of existing models and accepted among communities involved in their development. Among the patterns studied are the Transmodel the SIRI, the IFOPT and TransXChange in this section.

A. Transmodel

The data model is the European reference for information on Public Transport [2]. Defines an abstract model of common concepts for public transport and also data structures that can be used to provide different types of information systems of public transport. It is defined, for example, management of schedules, invoices, operational management, real-time data and travel planning.

This pattern contributed to the modeling of systems such as Operation Support System (OSS), the case that a system for monitoring and control of real-time operations.

It should be noted that the Transmodel established a consistent terminology to describe the concepts of public transport, defining a modeling language and common understanding for all participating nations. For example, the terms trip, journey or service are concepts with similar meanings that in Transmodel, are used only in very specific cases.

The Transmodel is currently in version 5.1 (version 6.0 "draft") created by SITP (Système d'Information pour le Public Transport), a program sponsored and supported by the French Ministry of Transport, which also supports the site of Transmodel (http://www.transmodel.org/en/cadre1.html).

Standards like TransXChange, Trident, SIRI among others, were developed based on Transmodel.

B. SIRI

The Service Interface for Real Time Information (SIRI) is an XML protocol designed to enable the exchange of information in real time between vehicles and public transport
services and distributed computers [3]. This protocol is a specification technique, developed with the initial participation of several countries: France, Germany (Verband Deutscher Verkehrsunternehmen), Scandinavia and the UK (RTIG).

The SIRI provides diverse information and focuses on schedules, vehicles and connections; also includes general information messages related to service operations. The information can be used for many purposes, as for instance:

- Providing information in real time to the departure time on the panels of the stops, Internet or mobile devices;
- Providing information in real time the progress of a particular vehicle;
- The management of the routes of vehicles when they circulate in areas covered by different servers;
- The management of synchronization of different service delivery and information processing;
- The transfer of information from planned schedules and schedule changes in real time;
- The distribution of status messages from various services;
- Providing information about the performance for recognition of historical or other management systems and decision support.

The aim of this interface is to incorporate the best of several proprietary standards across Europe and integrate them into XML Schema, providing their services on a layer supported by the European Committee of standards, developed with the initial participation of seven countries: France, Germany, Scandinavia, and the UK.

The communication layer integrates all functional services offering them: (1) Security; (2) Authentication; (3) Negotiating versions; (4) Recovery and Restart; and (5) Access Control.

In order to withstand the most varied operating conditions are used the two main patterns of interaction: (1) Request / Response immediate; (2) Publication / Subscription asynchronous.

C. IFOPT – Identification of Fixed Objects in Public Transport

The IFOPT is a technical specification European Committee for Standardization (CEN) which provides a reference model for data description of key public infrastructure needed for fixed public transport, ie the representation of airports, bus stations, seaports - as well as their entries - platforms, interfaces, equipment, accessibility, [4]. Such a model is a fundamental component of the infrastructure of information systems of a modern public transport network that wishes to offer its users the most complete information about your service. The IFOPT aims to: (1) Identify relevant functions that require unique identification of fixed objects, specifically in the field of passenger information in a multimodal context and multi-operator; (2) identify the main fixed objects related to the public transportation system, from a certain viewpoint, for example, considering a particular level of granularity returned from the description, taking into account the needs of the identified functions; (3) Provide a typology of objects represented and their definitions; (4) introduced relationships between objects in the system; (5) Describe unequivocally domain objects through their properties and attributes; (6) Describe how to locate objects in space, using geographic coordinates and links to topographic objects that have a clear separation between the transport layer and the layer topographic public; and (7) Allow the assignment of responsibility for the management of data at a fixed object.

The format is recognized and adopted in the UK and sponsored by the Department of Transport in the UK. The pattern is part of a cohesive family of XML-related standards, which follow best practices GovTalk in the UK, being based on the conceptual model Transmodel.

D. TransXChange

TransXChange is a data standard adopted in the United Kingdom. It is based on XML to transfer information routes and timetables between bus operators, the vehicle and the operating company, and between other entities involved in the provision of passenger information [5].

The format is recognized and adopted in the UK and sponsored by the Department of Transport in the UK. The pattern is part of a cohesive family of XML-related standards, which follow best practices GovTalk in the UK, being based on the conceptual model Transmodel.

The TransXChange can be used to exchange the following information: (1) Schedules including bus stops, routes, matches, frequency / time, operational notes and maps; (2) The day that the service runs, including the availability holidays and other exceptions; (3) The number of organizations such as local education authorities, schools and others, served by shuttle information with closing times of service; (4) Information on the operating company responsible for the service running; (5) Additional operating information, useful for SAE systems and ticketing systems.

In the new version of TransXChange is proposed to cover the standard FareXchange trouble ticketing and billing. The TransXChange can also be used for other means of transport, is currently used in metro and trains.

IV. COOPERATIVE TRANSPORTATION INFRASTRUCTURE

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 [6].

The data integration is based on a domain ontology (Ontology for Public Transportation - OPT), a wrapper that performs the mapping between different public transportation database models and a mediator. If the public transportation operator database 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 [1]. 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 database 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.

![Fig. 1 Different sources of public transportation data integration approach](image1)

VI. SITP APPLICATION

This Section is dedicated to the description of the SITP application developed for the public transportation data integration. In Figure 4, it 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.

![Fig. 2 Platform D2RQ used at wrapper components [6]](image2)

V. TRANSPORTATION BEST ADVICE AND GREEN ROUTE PLANER

The main idea is to build an integrated system, as showed in Figure 3, that based on traffic and weather information, can give the best advice in terms of a diversity of options: public transportation from several operators, car and bike sharing system, and car pooling. 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, car pooling and bike sharing systems. With all information in a graph, the best path algorithm, described in [8], 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.

![Fig. 3 Cooperative Transportation best advice](image3)

The arc weight can be constructed from a diversity of options, time, price, and C02 emissions for a green policy.

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 CO2 emission price and a good investigation topic is to find the best combination between time, price and CO2 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 [9].

![Fig. 4 Use case for SITP application](image4)
VII. CONCLUSION

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 should allow 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 tourism, helping tourists to reach POI (Points of Interest) by public transportation.

APPENDIX

To search for Public Transportation routes were considered several criteria’s: The first is based on the selection of operators connected with the research. The second considers the number of transfers and price of the desired trip; and the last based on the trip duration using best path algorithm. In Figure 6 is described in a sequence diagram the search process. The first’s steps are the operator registration, where it receives an ID and publish the DB schema. This approach is combined with best path algorithm described in [9].

REFERENCES


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