Design of an exchange information component of O/D matrix for mass transportation systems based on DATEX II approach.

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Abstract— Nowadays, the mobility is a growing problem that worries the governments in Latin American countries. In fact, to improve the mobility the transportation planning process and the ITS technologies are key areas, which should work together to give solutions to solve or mitigate the problem. One of the most used tools in transportation planning to face this problem is the origin/destination (O/D) matrix, which is used to estimate the moving of users and future demand on transportation systems. Nevertheless, the current technologies for the generation of traffic data information, the matrix O/D in this case, create a new problem for handle the heterogeneous data especially for the traffic centers, which use these data for traffic management. The novelty of this paper is focused on the design of an exchange information component, which send the O/D matrix information to the traffic centers based on DATEX II approach.

Keywords-, intelligent transportation systems, O/D Matrix, DATEX II, Transportation planning, Exchange information, homogenization.

I. INTRODUCTION

Currently, the transport is the core of the life in the cities, because it is an important structure in the development of the society and the cities. However, there are several problems to resolve such as: mobility, traffic jam, toll gates collection, etc. In fact, the problems on the transport sector are an important issue for the governments and companies, which are investing in research and technologies to face them. The intelligent transportation systems (ITS) are the responsible technologies for supporting, improving and mitigating these problems.

Nevertheless, in Latin America context, the ITS technologies are focus in areas associated with the mobility, especially for mass transport systems. The interest on this area in specific, is due to the high concentration of population in urban centers, the World Bank statistic points out that in 2014 was 79.6% [1].

Therefore, to help improve the efficiency of the mass transport systems and the mobility, the transport management centers should be supported by systems and tools which give information for a better planification. The O/D matrix is one of this tools which specifies the travel demands between the origin and destination nodes in the transportation network. In point of fact, the O/D matrix has information to improve the route planning, reduce cost and reduce travel times [2].

On the other hand, the ITS technologies for gather traffic information use several kind of data forms, content, sources and formats; which make more difficult the integration of systems and the interoperability with traffic management centers. These heterogeneous data sources are becoming a challenge for harmonization and standardization of data structure and exchange services, generating the need to create a standard for regulation.

In light of this, DATEX II has been developed to provide a standardized way of communicating and exchanging traffic information between traffic centres, service providers, traffic operators and media partners. This specification provides a harmonized way of exchanging data across boundaries, at a system level, to enable better management [3]. This standard is widely used over Europe on different scales and stages of development. The main usage areas includes network management and traffic management planning, line control systems, car-to-infrastructure systems and multi-modal information systems.

Therefore, this paper is focused on the design of a new component for data information exchange of the O/D matrix generated for the system created in the previous work [4] [5], with the aim to exchange information with the traffic management centers through the standard DATEX II. The main aim is to aggregate a new component which feed the traffic centers with O/D matrix information generated by the system.

The remaining of this paper is organized as follows. Section II describes the contextualization and related work. Section III proposed of the new component for the architecture. Section IV is focused on the description of DATEX II. Section V details the experimental work with the xml generated by the

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model. Finally, section VI contains the conclusions and the future works.

II. CONTEXTUALIZATION AND RELATED WORK

The public transportation and its planning are transversal and important components of infrastructure of cities, providing opportunities for the movement of people and goods, and connection between locations of living, work and activities [4]. Solutions like the bus rapid transit (BRT) represents a key part of the mobility, especially in Latin American cities where it was implemented as a response to dysfunctional and inefficient transport conditions [5].

To estimate moving users and future demand on the transport systems, like BRT an O/D matrix approach could be used. With this in mind, we developed a web service platform focused on the automatically generation of O/D matrix trough the signals received by two sensors that measure Bluetooth signals. It was implemented over the service-oriented architecture (SOA) and our proposal was explained in previous studies [6] [7].

Our ITS solution uses a Web Services technology to integrate heterogeneous systems and works from mobile devices and traffic centers; however, due to the need of information services homogenization and standardization of exchange information process; the implementation of a specification or standard is required.

Therefore, DATEX II appears in response to a harmonized way of communicating and exchanging traffic information across boundaries. It was developed by European normalization institute CEN and brought about to play a strong role for the implementation of integrated ITS in Europe (CEN/TS 16157:2011). DATEX II provides a rich and deeply structured data model specified using the Unified Modeling Language (UML), this model has three levels of specification that allow to extend the generic model (Level A, B and C [8]). As well the data model could be profiled into smaller better maintainable parts.

The DATEX II exchange process starts when the data model is mapped to information encoded in extensible markup language (XML) by automatically creating an XML schema definition and then concrete mappings are widespread trough HTTP protocol for simple exchange systems and Web Service's protocols (WSDL & SOAP) for exchanges with higher functional requirements [9].

Over Europe this standard is widely used on different scales and stages of development. The domain coverage of DATEX II is traffic and travel information exchange between traffic information centers. The main types of traffic information already cover by this standard are showed in Table 1. Unlike parking information the other types of data are covered by the level A of the model and do not need extension model.

Traffic information
Road works and streets works
All types of incidents and accidents
Road infrastructure status
Closures, blockages and obstructions
Levels of service on the network
Closures, blockages and obstructions
Road weather
Public events with impact on traffic
Parking information
Variable message sign

Table 1. DATEX II data model coverage

There exist many examples of successful DATEX II integration that can be considered as a guide for implementing the standard. One of these examples is from Germany where they integrated DATEX II to the mobility data marketplace (MDM) which is responsible for delivering services and infrastructure, managing information and developing communication solutions between data provider, data consumer and data refiner (See Figure 1). They offer data about traffic messages, roadworks, parking data, weather information and other traffic data through this standard [10]. By the same way, another project was focused on the implementation of an intelligent truck parking (ITP) profile. It deployed a pilot experiment on motorway A9 between Munich and Nuremberg, based on the relevant data provided by MDM [11] and where the truck drivers can check parking situation along their route using channels as smartphone apps, navigation systems in their trucks, broadcast messages and information kiosk at rest areas [12].

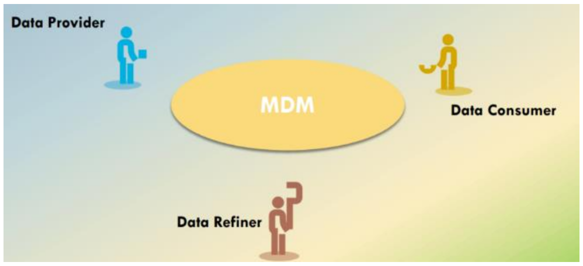

Figure 1. Mobility Data Marketplace *[13]*

In addition DATEX II system integration has been widely investigated from different angles. For example, the evolution of DATEX II to a semantic approach using Ontology Web Language (OWL) features which allows to describe with a logic language all relationships and interactions between the concepts of traffic. This approach helps developers to build intelligent transport systems more simple and efficient [14]. Another approach is the implementation of the standard as a part of software as a service (SaaS) by the National Traffic Information Service (NTIS) in England [15].

Our proposal takes advantage of DATEX II in order to exchange traffic information about the O/D matrix to determine how people are moving through public transportation network. We developed a publication extension for O/D matrix information through the design of a level B data model which support static and dynamic information. This means that we can give a great solution to support the organization and planning for public transportation systems in Latin America.

III. PROPOSAL

A. *Description*

As was mentioned above, we developed a web service platform for generate automatically the OD matrix to support the transportation planning and analysis of the mobility in mass transportation systems. Our proposal is explained in previous researches [6] [7], but briefly described, the system process the data gathered by Bluetooth sensors installed in the public transport network to construct automatically the OD Matrix, using algorithms based on filters. The web service platform take advantage to SOA approach for the homogenization of services, which allows us to give access to these data from different places, platforms and devices.

The focus in the presentation of data for users involved in the transportation planning, led us to create a new proposal to involve the traffic management centers as an external system, which could take advantage of the web service platform information as well.

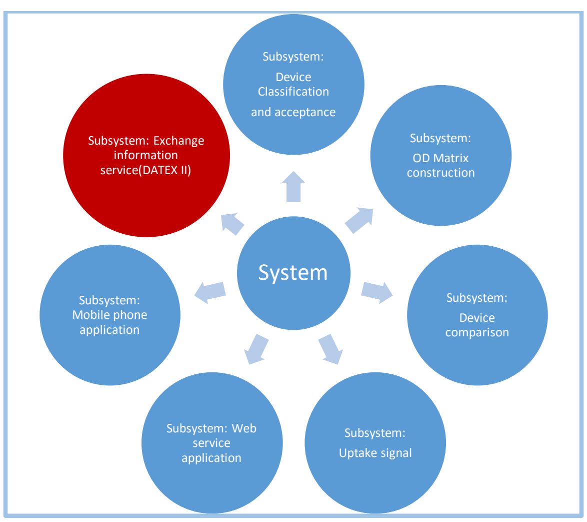

Figure 2. System architecture with the new component

The traffic centers in the most cases are responsible for dealing with cross boundary traffic management and service providers, etc. [3]. They are the heart of many ITS applications, therefore, the aim of the new component is to exchange the information especially with the traffic centers.

The actual structure of the data generated by the web service platform is not compatible with proposed external systems. For that reason, we decided to add a new component based on DATEX II standard, which allowed us the homogenization of the information exchange.

The new component added to the architecture of the system can be seen in the Figure ***2***2 and it is highlight in red color. The architecture of the web service platform based in SOA paradigm, allow us to add new components without affect the current system.

B. *Exchange information component*

The exchange information service is a new subsystem based in DATEX II, with the aim to exchange data from OD matrix with other external systems, using a common structure of data exchange.

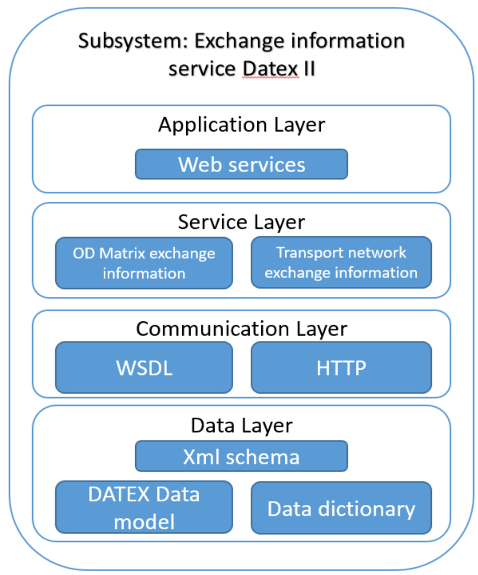

Figure 3. Exchange information service component architecture.

The detailed description of the component is presented in the Figure ***3***3. As can be seen the subsystem is divided in 4 main layers. The first one is the application layer which works over HTTP protocol and is composed by web services. It is important to highlight, this layer works over the mode client pull of DATEX II, due to the external system has to request with the system parameters (initial date and final date of the matrix estimation) to get the desired OD Matrix.

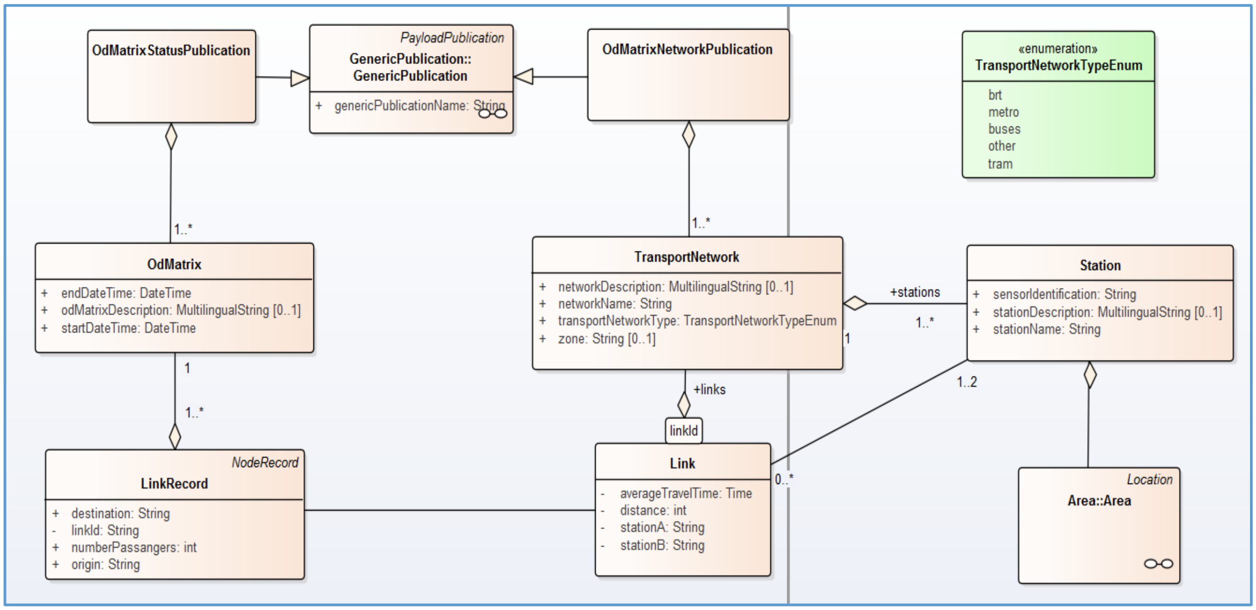

Figure 4 DATEX II Data Model- O/D Matrix extension

The service layer describes the services of the subsystem, in this case the OD matrix exchange information which is the dynamic information for exchange, whereas that transport network information is the static information.

The data layer contains the data dictionary with the concepts and attributes of the system, the DATEX data model and the XML schema.

IV. DATEX II DATA MODEL

In order to achieve our goal, a level B data model was designed to exchange static and dynamic information related with O/D matrix. Regarding the static information we purpose to exchange data about the transportation network where such matrix is used and concerning the dynamic information the values of the O/D matrix for a specific time period are sent to the traffic management center.

We designed a data model which is composed by two DATEX II publications derived from "*GenericPublication*" (See **¡Error! No se encuentra el origen de la referencia.**4). The "*OdMatrixNetworkPublication*" is used to publish static information of transportation network. It covers the transport network type like BRT, metro or buses, also includes the station and routes specification. Moreover, basic information about the sensors is included in order to identify which and where sensors are deployed over the transport network and description of the links which compose the O/D matrix, including the average travel time and distance between two stations.

The "*OdMatrixStatusPublication*" is used to publish dynamic information and the values of the O/D matrix. This publication is covered with three main classes, "*OdMatrix*" which contains the basic description and the range of time of the generation of the matrix. The "*LinkRecord*" class which contains the number of people who travel from one station to another one, the origin and destination station; and the link identifier which was described in the static publication.

V. EXPERIMENTAL WORK WITH XML

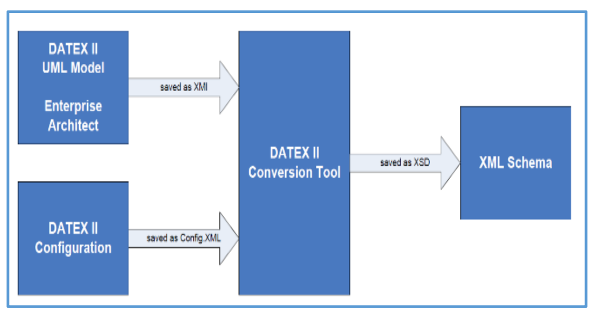

Figure 5. UML to XML conversion flow [16]

The Figure 5 points out the data conversion flow from UML to XML. This flow starts on DATEX II data model where we used Enterprise architecture software to incorporate the publications designed and to produce the XMI (XML Metadata Interchange). Then, a configuration file is required to control the conversion process and trough a DATEX II conversion tool the transformation process from XMI file to XSD schema takes place which is used to check and validate the XML generated. For instance, the O/D matrix publications were generated into two XSD files, one for static information and another for dynamic information these was validated with Altova´s XML Spy and by the conversion tool itself.

Based on the mentioned schemas was elaborated a group of XML examples in order to observe how the information are going to be sent to traffic centers. These XML's are based in the stations evaluated for the project in previous work [7], Mazuren and Av.Jimenez. From the static information is deployed the data about these stations, the sensors and the links. (See Figure 6). Each station is identify by the name and the sensor identification attribute, which is used as the unique key of the station. Regarding the links (routes), they are described by a link id, the average travel time, distance and it is related to two stations described before trough the sensor identifier.

```xml
<odMatrixNetworkPublication>
    <transportNetwork>
        <stations>
            <station stationIndex="1">
                <station>
                    <sensorIdentification>
                        HBFFE34221001-Mazuren
                    </sensorIdentification>
                    <stationName>Mazuren</stationName>
                </station>
            </station>
            <station stationIndex="2">
                <station>
                    <sensorIdentification>
                        HBFFE34221002-AvJimenez
                    </sensorIdentification>
                    <stationName>Av.Jimenez</stationName>
                </station>
            </station>
        </stations>
        <links>
            <link linkId="link-001">
                <averageTravelTime>40</averageTravelTime>
                <distance>100</distance>
                <stationA>HBFFE34221001-Mazuren</stationA>
                <stationB>HBFFE34221002-AvJimenez</stationB>
            </link>
        </links>
    </transportNetwork>
</odMatrixNetworkPublication>
```

Figure 6. Static information about transportation network in XML

The second example specifies the dynamic information, it includes the range of dates in which the O/D Matrix is calculated (In this case the peak hour from 7 am to 9 am), and the number of people which move from Av.Jimenez to Mazuren and vice versa (See Figure 7). It is important to highlight that link record is the representation of one node information in the O/D matrix.

The static information and the dynamic information are related through the sensor identifiers and link identifier. That means, a link record has to be linked to an origin, destination and a link previously described by the static part.

The data deployed in the XML mentioned above can be visualized on the web application as the following figure 8 showed.

```xml
<odMatrixStatusPublication>
    <odMatrix>
        <odMatrixDescription>
            <values>
                <value lang="en">
                    Matrix OD Route Mazuren / Jimenez
                </value>
            </values>
        </odMatrixDescription>
        <startDateTime>
            2015-11-17T07:00:00.0
        </startDateTime>
        <endDateTime>
            2015-11-17T19:00:00.0
        </endDateTime>
        <linkRecord>
            <linkId>link-001</linkId>
            <origin>
                HBFFE34221002-AvJimenez
            </origin>
            <destination>
                HBFFE34221001-Mazuren
            </destination>
            <numberPassangers>120</numberPassangers>
        </linkRecord>
        <linkRecord>
            <linkId>link-001</linkId>
            <origin>
                HBFFE34221001-Mazuren
            </origin>
            <destination>
                HBFFE34221002-AvJimenez
            </destination>
            <numberPassangers>300</numberPassangers>
        </linkRecord>
    </odMatrix>
</odMatrixStatusPublication>
```

Figure 7. Dynamic information about O/D Matrix

	Mazuren	Av.Jimenez
Mazuren	0	300
Av.Jimenez	120	0

Figure 8. O/D Matrix from Mazuren to Av.Jimenez

VI. CONCLUSIONS

The article presented a new approach for exchange O/D matrix information generated by the system developed and traffic centers based on DATEX II. The proposed solution is highly innovative, because it involves several technologies of great penetration in any country and the latest standard for exchange traffic information which has already implemented in Europe and it will be a key topic for services homogenization in Latin American countries. The fact to speak DATEX II language for send to traffic management centers the information about the O/D matrix generated by the system proposed, gives a new approach to support the transportation planning and also allows to communicate easily with third parties.

Currently, we are continue working on the project and in the further work we will implement the exchange information component over Web Services and test the efficiency and functionality of these services.

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VIII. REFERENCES

[1]. World bank, "Urban population (% of total)," 2014. [Online]. Available: http://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS/countries/1W-ZJ?display=graph. [Accessed 5 December 2015].

[2]. Cascetta, E.; Postorino, &, "Fixed Point Approaches to the Estimation of O/D Matrices Using Traffic Counts on Congested Networks. Transportation Sciencie informs," pp. 134-147, 2000

[3]. Datex II, "DATEX II – The standard for ITS on European Roads," 2011. [Online]. Available: http://www.datex2.eu/sites/www.datex2.eu/files/Datex_Brochure_2011.pdf. [Accessed 8 December 2015].

[4]. G. A. P. C. Prattley, "Guidelines for preparation of integrated transport plans," [Online]. Available: http://www.planning.wa.gov.au/dop_pub_pdf/guidelines_integrated_transport_whole.pdf. [Accessed 29 02 2016].

[5]. D. Hidalgo, "Contribuciones de Transmilenio a los sistemas de Transporte Masivo de Alta Capacidad en Buses (BRT)," 2012. [Online]. Available: http://www.itdp.org. [Accessed 20 10 2015].

[5]. Herrera-Quintero, Y. Canon-Lozano, A. Melo-Castillo, C. A. Gomez-Perilla and K. Banse, "Web service platform for automatic generation of O/D matrix for mass transportation systems," in 13th ITS Telecommunications (ITST), Tampere, 2013.

[6]. Herrera-Quintero L. F, Banse K, Cañon-Lozano Y, A. Melo-Castillo A, Gomez-Perilla C. A., "Web service platform for automatic generation of O/D matrix," EURASIP Journal on Wireless Communications and Networking, vol. 2014, p. 115, 2014.

[7]. E. Commission, "DATEX II v.2.3- User guide," 2013.

[8]. C. W. H. J. Lv Wei-feng, "Research on a DATEX II based Dynamic Traffic Information Publish Platform," in Second International Symposium on Intelligent Information Technology Application, Shanghai, 2008.

[9]. A. Rydzek, "MDM – Mobility Data Marketplace," Presented in DATEX II user forum, Prague, May 2014

[10]. J. Neugebauer, "Datex II itp profile implementation experiences," Presented in DATEX II user forum, Prague, May 2014.

[11]. Siemens, "Truck parking information system sitraffic conduct+," [Online]. Available: https://www.mobility.siemens.com. [Accessed 22 02 2016].

[12]. J. Schade, "Parking information in German MDM," in DATEX II User Forum, Prague, 2014.

[13]. D. T. Garrigos, J. J. S. Zapater and J. J. M. Dura, "Dealing with Traffic Information and User Profiles a Semantic Approach Based On Datex II," Intelligent Transportation Vehicles, vol. Book Series: Mechatronics Series 1, pp. 51-66, 2011.

[14]. I. Wells and D. Paulo, "Next generation traffic information services," in Road Transport Information and Control Conference 2014 (RTIC 2014), London, UK.

[15]. E. Commision, " DATEX II - schema generation tool guide," 2013.