ARCHITECTURE AND SPECIFICATION OF A SOLUTION TO CALCULATE OPTIMIZED ROUTES WITHIN A CITY FOR PEOPLE WITH REDUCED MOBILITY

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Abstract - In this paper we present an analysis on the information made available by the city hall of Viana do Castelo, a city in the North of Portugal, regarding routes of the historical centre of the city and their characteristics that can be relevant for recommending optimized routes to people with reduced mobility (permanent or temporary). Some characteristics include the useful width of sidewalks, largest width of crosswalks or regular floor of sidewalks. Based on this information, we present the architecture and specification of a solution that includes a mobile solution that can be used by disabled citizen to get optimized routes to walk within the city based on their disability.

Keywords - Urban mobility; disabled people; mobile solution.

I. INTRODUCTION

The growth of cities is increasingly done at an amazing rate. Increased economic power in more developed countries has been reflected in an increase in the number of vehicles within cities, which causes serious problems in terms of urban mobility, which represent the conditions that are created to citizens, so they can easily move inside the city and between its major places, using cars and public transportations. Urban mobility plans are being developed by municipalities to assure that these conditions are provided. Several causes exist so these plans assume a great deal of importance: the growth of the number of people within cities, the increasing number of roads being built, the different and growing number of transports within the city, the need people have of moving within the city several times during the day because of their jobs and personal activities. Urban mobility targets both pedestrians and drivers, which are two very different perspectives that require different approaches also. In this paper, we focus on a particular case of pedestriansthat are probably more affected than the rest of the population by urban mobility problems: people with temporary or permanent mobility difficulties such as visually impaired people, people in wheelchairs, elder, pregnant ladies, among others.These people face enormous difficulties in their mobility through the streets of the city, because they need to use walks with minimum widths, need to know obstacles that exist in the route, streets with a lot of slope, among other important aspects.The creation of tools that help these people have to be very flexible and rapidly changeable as the streets can quickly change their configuration, for reasons of construction, opening of a new cafe with esplanade, installation of a new post lighting or any other object whatsoever In this work, we present the architecture and specification for a solution to be implemented in the city of Viana do Castelo, in the north of Portugal, in partnership with the city council, taking into account a set of routes from which a survey was made to gather information of what streets are more advised depending on thedisability ofcitizen. The proposed solution encompasses a mobile application that will allowcitizens to receive real time and optimized information of a route based on hisdisability. Also, the city councilwill have access to a back-office web application to manage all information allowing changes to the routes to be done in a quick and easy way. An algorithm will go through all route stored information and recommend an optimized route to a given user, depending on his disability. The rest of this paper is structured as follows: in the following section we present the literature review regarding solutions within the scope or urban mobility. Section 3 introduces our proposal starting with the contextualization of the case study that motivates this work. Next, we describe in detail the architecture, relational model and first mobile UX prototypes. Finally, we discuss some aspects that brought the project to this stage andpresent conclusions and future work.

II. LITERATURE REVIEW

There are currently several studies being carried out to fight the problems of urban mobility, both for drivers and pedestrians. One of those studies targets multimodal travels, where a range of complementary transportation services are offered to an individual (Ulloa et al 2018).A Traffic Management System alternative that considers population information is another contribution, where the system APOLO is presented, which employs historical knowledge of mobility patterns of the drivers to obtain a global view of the road network (Akabane et al 2017). Seeking green transportation is the purpose of another study which investigates big urban traffic data to characterize essential features of urban mobility and construct large-scale green urban mobility models

(Xia et al 2018). Estimation of urban mobility is addressed in (Vidović et al 2017) where authors propose a method that provides an estimate of the movement of users in order to estimate urban mobility by forming an origin destination matrix, travel time matrix and distance matrices between the respective zones. Other similar research uses data collected from citizens' mobile communication as the foundation to feed tools that inform city planners (Senaratne et al 2017).

Creating a barrier-free city is one of the challenges that urban mobility faces. Developing pedestrians' applications requires data that is generally unavailable in a user-consumable format. To address this, some authors propose a routing solution for pedestrians with disabilities (Bolten et al 2017).Infoblu Traffic for Expo is a free mobile appprovides end-users with integrated real-time in-formation about urban mobility in and around Milan through a map-centered representation of the real-time traffic data that Infoblu directly collects (Cerino et al 2015). The different requirements for the elderly, physically impaired people, blind and woman in pregnant is addressed in (Cho et al 2017) where authors analyse the requirements for people with permanent or temporary disabilities and present an architecture for smart navigation.

III. PROPOSAL

3.1 Contextualization

The city of Viana do Castelo has created the Accessible Tourism Roadmap which is a document in which the public and tourist buildings in the Historic Centre of the city of Viana do Castelo are highlighted, as well as the different routes accessible to all of them, in order to facilitate the choice, for part of the population that inhabits or visits the city of Viana do Castelo, from the best routes to reach them, according to mobility difficulties. The routes are classified based on mobility characteristics which generated three groups: people in wheelchairs, people with sensory difficulties (that include deaf and blind people) and temporarily conditioned person (that include pregnant ladies, child and elder people), as illustrated in Figure 1.



Figure 1. Target groups based on mobility characteristics

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To start this project, we picked up on 30 routesin the historical centre of which the city council had gathered information about. All routes have the same beginning- the Interface (bus stop and Shopping centre -andgo byseveral key reference points in the historic centre of Viana do Castelo, such as public services, health units, cultural spaces and tourist offices, detailed in Table 1. The purpose was to define several routes that cover majority of streets and most important places citizens can go to.

Table 1. Key reference points, grouped by category, served by the routes designed in the historical centre

Type of reference point	Places
Public services	Viana do Castelo City Hall; Finance Service and Labor Court; Post Office and Judicial Court; Civil Registry Office; Conservatory of the Land Registry; Commercial and Automotive; Social Security; Police; Labor Conditions Authority; Information and Mediation Service for People with Disabilities.
Health Units	Santa Luzia Hospital; Health Centre; Gil Eannes Family Health Unit.
Cultural Spaces	Municipal Library; Municipal Theater Sá de Miranda; Costume Museum; Museum of Decorative Arts; Church of S. Domingos; Nichos House; Old County Councils; Church of Mercy; Republic Square; Mother Church; Chapel of Souls; Field of Agony; Santiago Bar Castle; Cultural Center of Viana do Castelo; Santa Luzia.
Touris Offices	Viana Welcome Center, Tourism Office.



Figure 2. Route with two-subroutes from Interface to Old County Council(Antigos Paços do Conselho)

Figure 2 shows an example of how each route were represented. Each route has several sub-routes,

depending on the target group. The creation of severalsub-routes, from an origin to a destination, depending on the type of disability, is the fundamental information that will allow to feed a mobile application that allows a person with a disability to be able to move within a city in a safe and optimized for his situation.Each sub-route starts in Interface and goes through different reference points in the city until a given destination. In Figure 2, an example is shown between Interface and Old County Councils with two sub-routes.

Figure 3 shows the detailed information of each sub-route of a route, the target group to which it is appropriate for and characteristics of the sub-route. In the example below, route 1 (green) is for people in wheelchairs, pregnant woman and elder and the characteristics of the route are the existence of few obstacles, less distance of the global route andlargest usefulness width of sidewalks. On the other hand, route 2 (blue) is optimized for blind and deaf people and is a route with few crosswalks and small unevenness.



Figure 3. Information of the target groups of each route

The 30 routes from which information was collected were characterized by the following parameters that will be fundamental to distinguish routes and find the most appropriate for a given disability:

- useful width of sidewalks
- width of crosswalks
- regular floor of sidewalks
- number of obstacles
- global distance of the entire route
- existence of differentiated berm
- number ofcrosswalks in thr route
- reducedunevenness
- inexistence of stairs
- less change of directions
- existence of safety bars on the berm
- pedestrian street,
- existence of differentiated central guide.

3.2 System Architecture

Considering the information gathered by the city council, the purpose of the project is to define an architecture that allows the representation and storage of all the information, so it can be processed to calculate optimized routes for each citizen.

The architecture we propose is illustrated in Figure 4 where two main intervenient can be seen.The city hall will administer the platform and manage all data that will feed mobile apps which will be used by the other intervenient in the design architecture: disabled people.

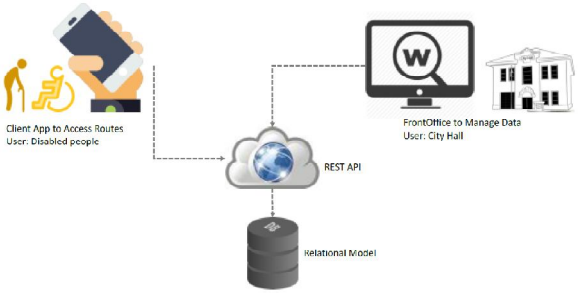


Figure 4. System architectureshowing two main intervenient: the city hall and disabled citizens

Referring to technological aspects, a MySql central database will exist and will be accessed via a REST API, using Slim Framework and NotORM.Figure 5 shows the three different layers that the system will have: a visualization layer, a processing layer and a storage layer. In the visualization layer, two different interfaces exist considering also the two main intervenient. City hall technicians will access a web platform that will allow to manage all data relevant to this system.On another hand, a mobile app also makes part of the visualization layer as this is the

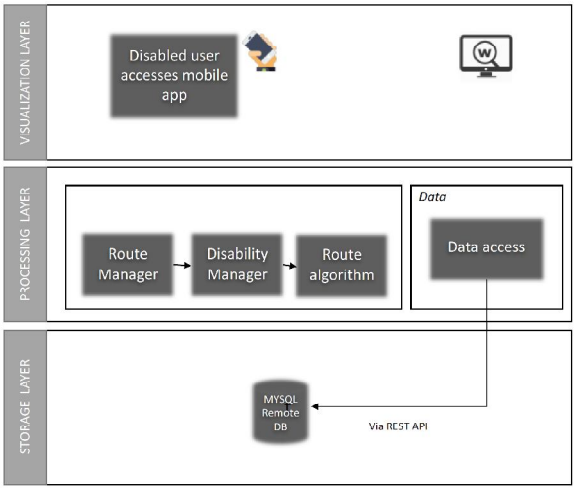


Figure 5. System layers that support the proposed solution

main interfacedisabled citizens will use to interact with the system. Both applications (web and mobile) make use of a processing layer that is divided in three major modules. The first is the Route Manager that is mostly used by the web platform and that handles all data related to routes. Another module is the Disability Manager that allows to specify the

characteristics of the route that are most important for each disability, so the more optimized route is given to the user. Finally, the Route Algorithm module is responsible for calculating optimized routes based on the disability of the user as well as characteristics defined in the Disability Manager.

3.3 Data Model

InFigure 6, we present a relational model that assumes the existence of certain information (routes) collected by a city council regarding routes and their characteristics, so that later this information can be used to calculate optimized routes, either in a web application or in a mobile application. It is assumed that each collected route consists of several points and is characterized by several aspects. The 'route' table saves the route with its description; the 'points' table saves the several points that can be part of routes and the 'routepoints' table stores the points that are part of a given route. Based on this structure, the calculation of a path must use the information of common points between routes (intersections) in order to find the optimal route between a given origin and a given destination.Additionally, each route also has aspects that characterize it as the width of walks, slope, etc. These aspects are stored in the 'aspects' table and the route association is in the 'route_aspects' table. Finally, it is necessary to specify the types of disability to which these routes respond, which are described in the 'disability_type' table. The 'dis_type_aspects' table holds information on the most important aspects to be taken into account depending on the disability, a priority field being included in this table so that the algorithm can first take into account the most important aspects of the disability.

3.4 algorithm

O algoritmo usado para cálculo dos percursos é o Dijkstra´s. Dependendo do tipo de deficiência, são extraídos da base de dados as características mais relevantes a ser obedecidas e são atribuídos pesos aos caminhos de acordo com a ordem das prioridades. O caminho mais curto é então calculado para apresentação ao utilizador.

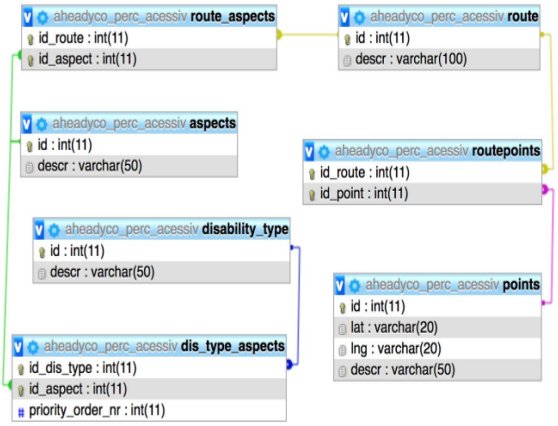


Figure 6. Relational model

3.5mobile prototype

A first version of the mobile applications has started to be developed and in Figure 7 we present some UX prototypes of the iOS version. The main screen intends to be simple and gather feedback from user regarding his disability. The next screen allows user to enter his origin (or choose his current location) and the destination he wants to go to. At this point, a list of points appears, based on the information in table 'points' so the user can choose one. A route is then presented with the result of the Dijkstra´s algorithm and the information in the database. The screens will still be improved regarding their usability as concerns about accessibility are not yet incorporated at this stage. Mobile apps for deaf, blind and elders need special attention and this work has not yet been done.

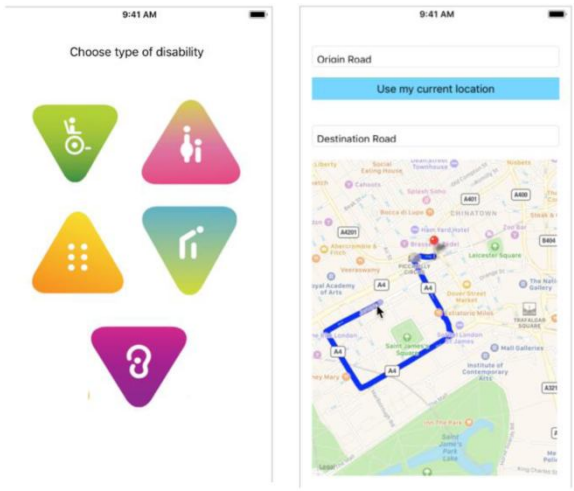


Figure 7. UX prototypes for iOS mobile application

DISCUSSION

To reach this point of the project, there were several meetings with the City Council of Viana do Castelo, in order to perceive the best way to provide information relevant to the disabled citizen. There was already some information collected on 30 routes and also a previous web application (Figure 8) that provides route information for citizen based on some criteria but obviously cannot be used in real time on the streets because it does not use the user's current GPS coordinates. Hence the need to develop a mobile application to be able to be used during the whole course. It was also concluded that the use of the app should be easier than the web application previously developed that allowed the user to choose the parameters (sidewalk width, etc.) that they want to be used for calculation of the route (this has revealed to be too detailed). Thus, it was decided that the mobile user would only introduce their disability and the relevant aspects to calculate the route would be obtained from a database that would be populated by the city council itself.

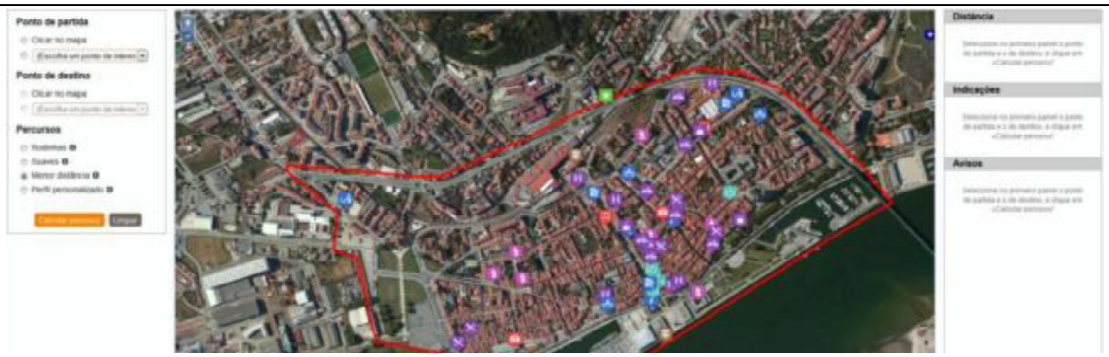


Figure 8. Previous web application developed for providing routes information to citizens

This point of view resulted in the architecture, data model, and UX prototypes presented in the previous sections, that are still on-going. Also, since the web application was developed, and the 30 routes were first defined, changes occurred in the city that require those routes to be redesigned and new characteristics to be associated to each route. To achieve this flexibility,the backoffice was also introduces as a requirement to be developed.

CONCLUSIONS

This article presents a contextualization and real needs felt regarding urban mobility in the city of Viana do Castelo, a city in the North of Portugal. In partnership with the city council, a solution is being designed that aims to provide accessible routes for people with some type of reduced mobility, including the elderly, pregnant and children, people in wheelchairs, blind and deaf. Based on a set of routes carefully surveyed and annotated with characteristics such as slope or width of the walks, it is intended to develop a mobile application that allows citizens, in real time, to obtain the best route given their disability. In this article we presented the architecture, relational model and UX prototype of the mobile application, which represents the result of the first phase of study of what will be developed. The solution also includes a backoffice that allows a city council to change the street information and its characteristics so that the most current information is available to the disabled citizen. Next steps include the finish of development of both mobile and backoffice applications, carrying out tests with users before publishing apps in the App and Play Stores to be available to everyone in need.

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