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DESIGNING AND IMPLEMENTING A WEB BASED NETWORK CONTROL SYSTEM (NCS) FOR AUTOMATED REAL-TIME ROUTING AND MANAGEMENT: A CASE STUDY FOR TEHRAN

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Abstract: In this paper, the design and implementation of an innovative web based network control system (NCS) is discussed. The NCS acts as a web service to manage a routing and traffic control system. The NCS offers a real time traffic control system via the web for classified users and a routing service for general users. Our test case is the city of Tehran where police, firemen and other officials have the authority to neglect traffic laws so that they can take different (and faster) routes than the standard users. The NCS is compatible with mobile devices and – very importantly – low speed internet. By using the NCS, the administrator is able to close or open a street or a specific segment of the target street and to update the street data stored in a relational database management system (RDBMS). The NCS employs two live search engines to find and manipulate a street or a street segment. It uses a text live search engine compatible with all major browsers to find the target street within the RDBMS and apply changes to keep the routing service real-time. A vectorial live engine is used for graphic interface, especially for the identification of road segments. The NCS development, prototypical implementation and applications are based on Open Source Software, Open Standards and Open Data.

Keywords: Web based spatial information system, Network Controlling System (NCS), Real time routing, Open Standards, Open Source Software, Open Data

DESIGN UND IMPLEMENTIERUNG EINES OPEN-SOURCE-BASIERTEN NETZWERKKONTROLLSYSTEMS FÜR ECHTZEIT-VERKEHRSMANAGEMENT: EINE FALLSTUDIE FÜR TEHERAN

Zusammenfassung: Der Beitrag beschreibt Aufbau und prototypische Implementierung eines Netzwerkkontrollsystems (Network Control System – NCS) zur automatischen Echtzeit-Routengenerierung und Administrierung eines Straßennetzes. Als Beispiel dient das Straßennetz der iranischen Hauptstadt Teheran. Hierbei wird je nach Nutzerberechtigung der schnellste Weg gemäß wählbarer Algorithmen berechnet. Während reguläre Fahrer den Straßenverkehrsregeln unterworfen sind, können autorisierte Nutzer wie Polizei- und Rettungskräfte den tatsächlich schnellsten Weg unter Vernachlässigung von Verkehrsrestriktionen wählen. Das NCS kann von mobilen Geräten auch bei Internetverbindungen mit niedrigen Geschwindigkeiten administriert werden. Es bietet Textsuche für das Auffinden von Straßennamen und eine interaktive vektorielle Suche zum Identifizieren von Straßensegmenten. Entwicklung, prototypische Implementierung und Anwendung basieren auf Open-Source-Software, Open Standards und Open Data.

Schlüsselwörter: Webbasiertes Informationssystem, Netzwerkkontrollsystem, Echtzeitrouting, Open Standards, Open-Source-Software, Open Data

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1 INTRODUCTION

Web services play a significant role in accessing and disseminating information. In fact, by using web services, applications on personal computers or mobile devices can be transformed to web applications and made accessible to other people without the need to install software on their computers. Different types of information are being disseminated by transmission devices in a fraction of a second. A user can open a mobile device such as a cell phone and appreciate a routing service in an unknown city to find the best and shortest direction to the desired destination. In contrast to general web sites, which are usually sealed off to external software systems, web services are considered open in that they provide programming interfaces that can be accessed by external applications. Geospatial web services provide leverage to the power of GIS, programming components, and the World Wide Web (WWW) to serve an expanding variety of needs (Pinde & Jiulin 2010).

There exists a growing number of research and technical projects around web based spatial information systems. A good example is the one that was implemented by Anderson & Moreno-Sanchez (2003). They designed a web based spatial information system using Open Source software (OSS) and Open Standards (OS) to support land use planning in Central Mexico. Chang (1997) designed a user friendly web based GIS for public participation. Another example is AMSIS, a web based interactive mapping and decision support system that improves the integration of government and non-government information in the Australian marine jurisdiction (http://www.ga.gov.au/imf-amsis2/?accept_agreement=on). Rafael (2006) developed and implemented a multimedia spatial information system to document yellow fever mosquitoes *(Aedes aegypti)* breeding sites and dengue fever risk along the US Mexico border. The system was based on OSS and OS and created a sensory-rich environment allowing users to explore connections among various heterogeneous datasets, to visualize information, and to reach their own conclusions. Sha (2009) built a spatial information system based on geospatial web services. The system enables users to take advantages of both online interactive map manipulation and high resolution images. Li et al. (2007) developed a web based forest information system using an Open Source software solution. In fact, in this research an attempt was made to program and test a geospatial web service for a real-time routing service over the web through a network control system (NCS). The NCS is a type of spatial information service to manage and keep the routing service real time and automated. Without the designed NCS, users can have a routing service that may be similar to other available systems like Google Maps but would not have the benefit of real-time or near real-time traffic information. Consequently, in our research we focus on the development of an operational NCS for real-time routing und traffic management using Open Source software (OSS) and Open Standards (OS).

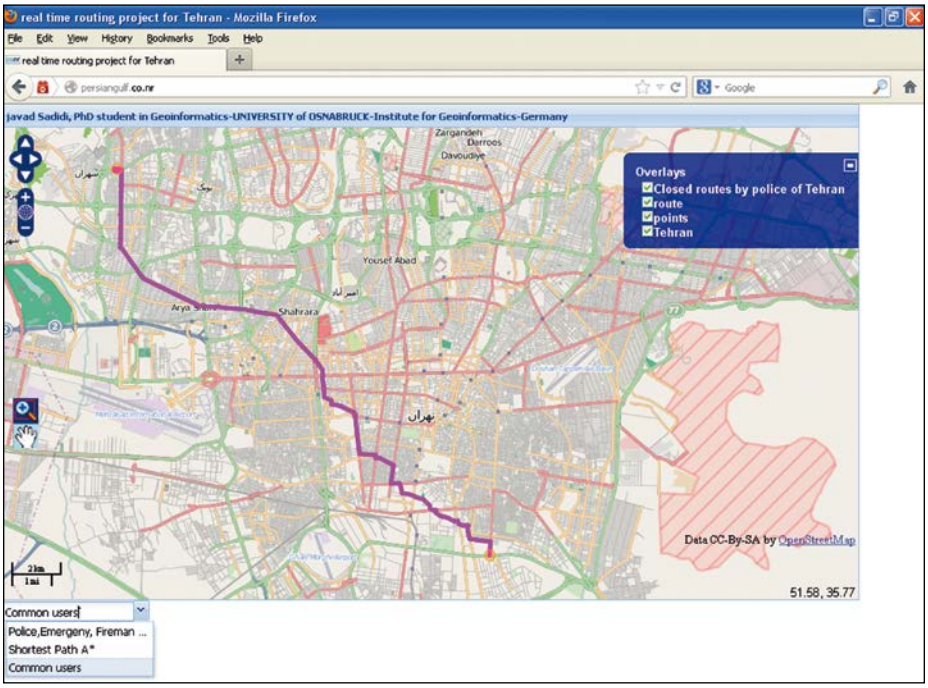

Figure 1: Simple web based routing service for Tehran for regular users using the A shortest path algorithm*

2 METHODOLOGY

2.1 NEED ASSESSMENT

Before the final design of the conceptual model, a need assessment study was conducted. At this stage, we consulted with related experts to gain information about the necessary requirements for the system. For example, policemen as administrators and users of the designed service stated what the police would expect from the service. 'Regular' users were also interviewed about their expectations to establish the system components. Based on their responses, the conceptual architecture of the service was designed.

2.2 CONCEPTUAL ARCHITECTURE OF THE NCS TO OFFER REAL TIME ROUTING SERVICE

Based on the need assessment stage the system consisted of the following components:

- A routing service to find the best possible route for all user via any browser.
- A security protected web page for control and management by the administrator.
- A text live search engine to search and to connect to the RDBMS, to find and apply changes for system update as a real time service.
- A vectorial live search engine to find, locate and apply changes for segments as a part of street. This is used when the administrator wants to manage a segment instead of the whole street because it is often needed to close/open a segment of the target street.
- Live drawing of the implemented updates including the display of closed streets or segments and the removal of opened streets or on segments.
- Live correction for the determined best route via the user's browser when an update is required.

2.3 SYSTEM STRUCTURE

After defining the framework for the system, the following software and data infrastructure has been realized. The implemented software makes use of the following Open Source Software and Open Standards: PostgreSQL with PostGIS and Pgrouting extensions, Ubuntu server 12.04 along with Apache server as the web application server, HTML5, Open Layers, ExtJS, GeoExt, XML and GeoJSON as the exchange format, PHP as the server side scripting language, JavaScript, Ajax, Jquery and SQL. To find the best route on the server, the Dijkstra algorithm as a non-heuristic method, A* and Shooting Star as heuristic models are implemented. For the NCS prototyping and testing, OpenStreetMap (OSM) data from Tehran were used.

2.4 PROGRAMMING AND IMPLEMENTING A SIMPLE WEB BASED ROUTING SERVICE

As a first step, we created a simple system to find the best route which was not yet supposed to be real time. The next steps would involve the development of an NCS for real time control and display.

Up to now, a simple web-based routing service has been programmed and implemented. Figure 1 shows the result on the user browser. The user selects interactively the start and destination point and the server provides the result of the best route. Default is the A* algorithm because of its speed and correctness.

2.5 NETWORK CONTROLLING SYSTEM (NCS)

2.5.1 PRINCIPLES FOR NCS DESIGN

Current routing web services are able to find the best route for users but do not offer real time management and control. The designed NCS should be based on the following principles:

- NCS should be a real time control and management system in which the administrator can control the system by his or her mobile device.
- NCS should offer different routing algorithms for different users. Police, emergency services or firemen use the algorithm which just considers the shortest distance whereas normal users must select the algorithm that also takes all traffic laws and restrictions into account.
- NCS should offer a segment management system in which the administrator can just close a single segment of a street and the routing service can use the remaining segments.
- NCS should be compatible with mobile devices and low speed internet connections.

2.5.2 CONCEPTUAL ARCHITECTURE OF THE NCS

After considering existing systems and consulting with transportation experts the conceptual architecture of the NCS was designed as shown in Figure 2.

The administrator (for example, a traffic police officer of Tehran) can open his/her mobile set, enter a secure service page and control the routing service over the web to keep it real time. When the administrator closes or opens a street/segment the designed service sends a warning to active user browsers in vectorial format and corrects the selected route automatically. In fact, the NCS enables the administrator to close or open a specific part of network and enables the users to be informed about the changes and be offered a real-time routing service by correcting the previously calculated route.

2.5.3 IMPLEMENTATION OF THE NCS AS A WEB BASED REAL TIME SERVICE

After designing and programming the components of the conceptual architecture (Figure 2) the system was implemented as follows:

- A virtual server computer offered by University of Osnabruck was used as server.
- Ubuntu 2012 server along with the necessary modules was installed.
- A domain name was registered for real-time web service for users (www.persiangulf.co.nr).

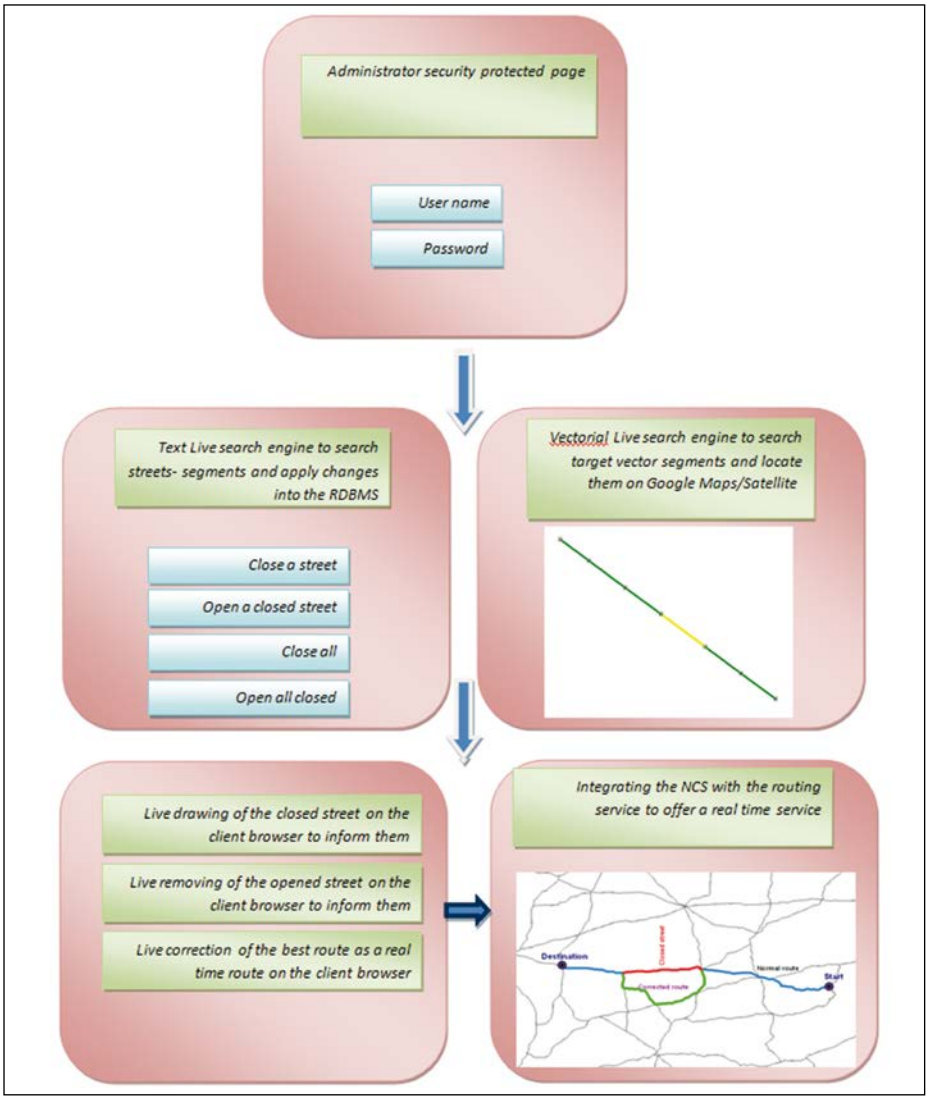

Figure 2: Conceptual architecture of the NCS

- A security protected domain name was registered for the administrator page (www.tehrannacs.co.nr).
- The programmed code was transferred to the server and redirected to their related domain names.

Figure 3 shows the final result of the web based real time routing service for clients (see www.persiangulf.co.nr). Red color shows the closed streets and pink shows the best route regarding to the closed parts. The web service at the client side exploits the following facilities:

- Layer switcher to control the visible layers.
- Scale, pan, zoom, move as map controls.
- Routing methods combo box selector for different users. Police, emergency, firemen and other officials can select different methods for faster routes.
- Live vectorial warning layer to display parts of the street network closed by the administrator.
- Live correction for the calculated best route.
- Start and destination control by mouse click.
- Mouse coordinate position display.
- Triggers that force the routing function to be re-executed including moving start and destination points, routing algorithms combo box selector and database updating.

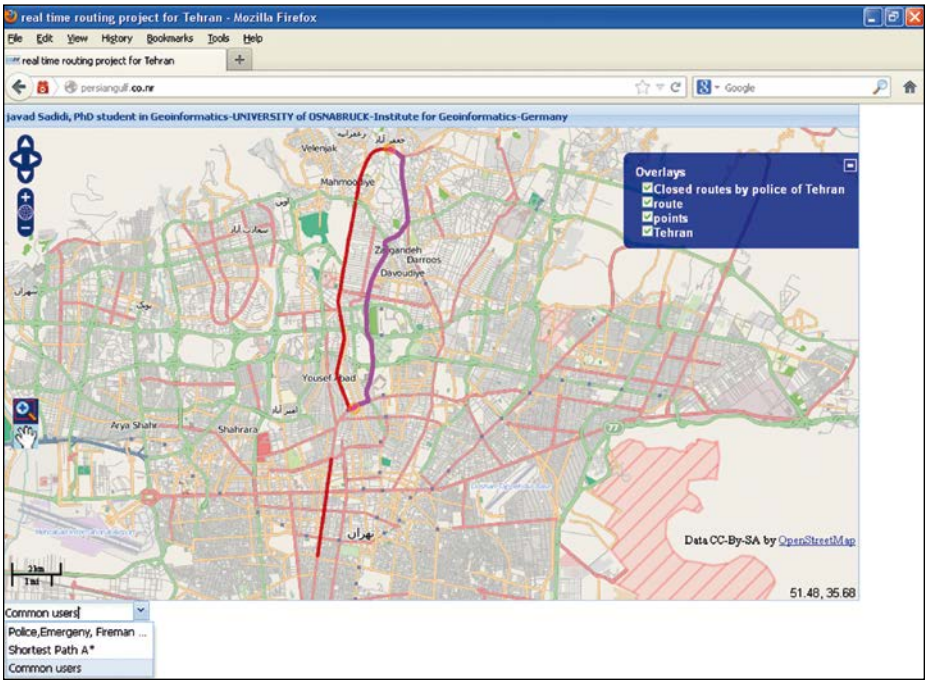

Figure 3: The final NCS routing service: red = closed streets/segments; pink = new best route for regular users

3 CONCLUSIONS

A real-time web based service, especially in big cities like the capital of Iran, helps people to save time and to manage adverse traffic situations. With no real-time and controllable system, the user may enter closed streets based on a previously calculated shortest path algorithm. Real-time control and warning increase the efficiency of the system. The NCS prototype provides control of the network and offers real-time capability to current routing services like Google Maps. The differences between a simple routing system and a system with NCS are the following:

- NCS allocates live vectorial warning for closed streets.
- NCS offers live correction for the best calculated route.
- Different algorithm selections are possible for classified users.

The designed system is so easy-to-use that even an administrator with just simple writing and reading literacy can control the network. The NCS is very useful for traffic police to control the streets and even small street subsets to avoid misdirecting drivers when an accident has happened and a part of the street network must be closed (see Figure 3). The NCS also is very important for other specialists, such as firemen and emergency ambulances because it takes into account their special routing requirements. The NCS technology may also be extended and modified to be used in other network systems like water, waste water, telecommunication, or facility networks.

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