reviewed paper

Mobile Intelligent GIS Service for Vibrant Cities

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1 ABSTRACT

In this paper we would like to introduce a concept of mobile service for safe navigation through city waterways. The main technology for storing, exchanging and processing data for this project is cloud services platform. The service provides a set of essential options based on context decision making support system and geoinformation system such as: alternative route planning, calculating safe distances between vessels, suggesting evasion options to avoid collisions, supplying warning messages etc. The potential users of this service are professional and non professional sailors on various vessels navigating city waters. As a conclusion we present a case study of safe navigation through city waterways in Amsterdam, Netherlands.

2 INTRODUCTION

Main trend of any modern city is constant change. Different construction sites, restoration works are common sight for most citizens of megalopolis. Modern city can go through the course of various radical transitions in span of years. New blocks grow like mushrooms and old ones transform into vibrant social centers. Such changes lead to alterations in city's economic and social infrastructure. Considering that the term “vibrant city” lacs clear standard definition, we shall understand the term as a city undergoing an escalating economic and population growth. Such city requires resources to sustain and organize internal infrastructure and maintain the quality of life of its inhabitants without excessively wasting natural resources. Economic development and rising number of citizens result in a growing strain on transport infrastructure. Not many European cities can claim that their roads and traffic regulations were designed to sustain the number of vehicles currently owned and used by their citizens. Thus, alternative multi-purpose means of transportation are highly desired.

One of the progressive alternatives of transportation in the city is through waterways. Water transport may become full-fledged analogue of the common land transport. Vessels allow to considerably unload road traffic through the city and are more environmentally friendly. They can be utilizes as private means of transportation, public transport with fixed routes, for economic activities (shipping goods, amusement activities and etc.).

However, navigation through city waterways is not a trivial task. Any person deciding to sail through the city will need aid in navigating growing water traffic. In many large cities there is a high density of water cargo traffic. Nevertheless, associated infrastructure is underdeveloped (lac of gas stations, service stations, docks for personal vessels and etc.). In a large number of countries sailing a personal vessel requires applying for special licence.

Thus, the issue of this paper is to introduce a concept of mobile intelligent geographic information system (IGIS) application which provides means to safely navigate city waters and monitor city water situation. In part 2 of this paper we overview some works related to this concept. Part 3 describes architecture of discussed mobile IGIS application. Part 4 is a functionality overview and a case study of safe navigation in Amsterdam, Netherlands.

3 RELATED WORKS

The paper (Petit at al., 2006) introduces the principles of a multi-dimensional contextual approach for adaptive GIS applied to maritime navigation. The research presented in this work regards a contextual-based modelling approach that considers users, appliances and geographical data as the core elements of an adaptive GIS: the model identifies and characterises different elements of geographical context (user, data, process and region of interest).

Example of safe navigation system development based on GIS is given in paper (Goralski, Gold, 2007). This work pays attention the issue of navigation monitoring in vessel's location area and aspects of system functioning in real-time. It is also important to note that this paper is dedicated to the problem of shipborne

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system development. Integration of external intelligent navigation system with suggested solution is regarded as one of the novel directions of research.

The concept of integration GIS with maritime navigation system is described in paper (Ray at al., 2007). The concept presents a framework with several integrated modules: anti-collision function (monitoring risk of running aground and evasive ship behaviour), traffic analysis module, simulation capabilities, modules for educational and training purposes. The users' interaction with the proposed system is focused on the concept of adaptive GIS (GIS automatically adapts according to its context) which is all oriented on proposing GIS as a decision-aiding system.

In the paper (Lam at al., 2007) authors focus on the issue of integrating web-based Marine Information System (MIS), the data formats of various nautical chart and geographic information system (GIS) applications to provide conditions for safe maritime navigation, protection of onshore and offshore assets and infrastructure. This work describes advantages of combining this types of data and technologies to expand their capabilities and enhance efficiency.

Solutions listed above do not let us objectively estimate ad prognose developing water situation in the city region. In this paper we suggest new solution for mobile water navigation task based on intelligent geoinformation system (IGIS). Under the term intelligent GIS we understand geoinformation system that includes integrated tools and/or systems of artificial intelligence (AI) (Popovich, 2013).

4 MOBILE IGIS ARCHITECTURE

Mobile IGIS architecture can be divided into physical and logical. In logical architecture functional interaction between elements of mobile IGIS is depicted. Under physical architecture we understand a specific physical realization for system, which satisfies logical architecture.

In the base of mobile IGIS physical architecture lies virtualization technology. This technology is also called cloud computing. Under cloud computing we understand wide and convenient network access to computational resources (e.g. networks, servers, storing facilities, applications and services). The cloud provides software and hardware resources via the Internet. Unlike classical computational models, cloud model includes services, clients, managed content and virtual machines.

Under web-services we understand means of connecting services together. Service is a software that performs some computing functions.

Basic technical realization of mobile IGIS visualization system is represented by two-level structure. On the first level virtual machine cloud is situated, that provides technical resources of all program services. On the second level is a computational virtual cloud that provides access to developed services and software. Figure 1 represents work of mobile IGIS.

On the lower level physical servers are based, where virtual machines are launched. Managing of this virtual machines, computational resources distributing, providing new virtual machines under increasing utilization, hardware monitoring are executed through virtual machine manager (e.g. oVirt). Such solution allows to equally distribute computational resources, to prognose strain on hardware and promptly plan its replacement.

In the virtual machine cloud services' cloud is unfolded, including instances of applications that are executing users' inquiries processing. Several levels can be distinguished in services' cloud:

1 level – virtual servers processing users' inquiries;

2 level – developed application and services providing specified services;

3 level – clients' level, applications installed on clients' devices that allow to use provided services.

Application provides centralized customization of mobile devices and network access via cloud.

Thereby, cloud services are designed to support interaction between users of mobile IGIS working together towards solving common tasks. Unified application instance, launched on server, attends to number of users while solving tasks.

Application of cloud computing concept gives a set of advantages. First of all, independence from the platform: users can use any convenient mobile devices and operation systems for their work. Also, all necessary applications user receives after connecting to the cloud. Automatized scalability of the cloud is a convenient feature for expanding functional capabilities of mobile IGIS. In clouds all calculations are executed on local server and resources of users' devices are not consumed. Moreover, virtualization of calculations helps to shorten consumption of energy and associated expenditures.

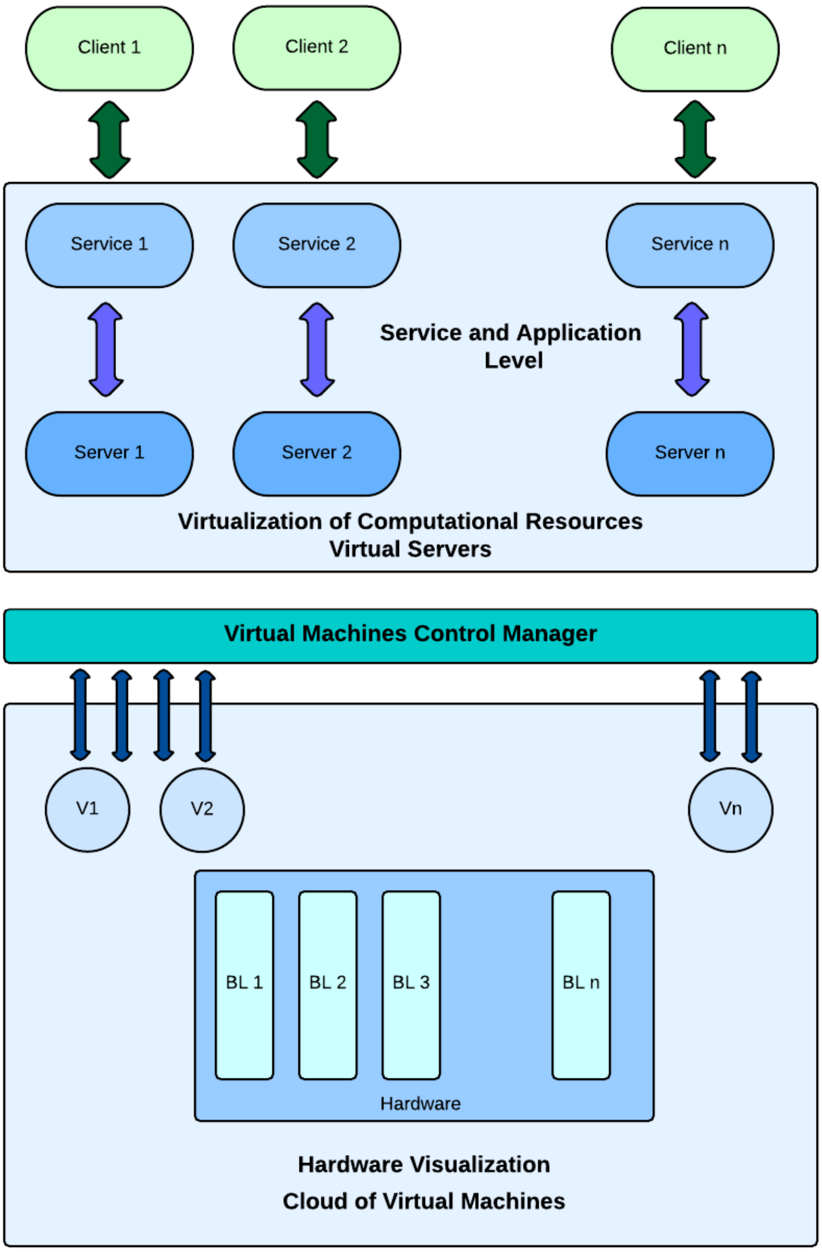

Fig. 1: Basic representation of virtualization system

Logical architecture of mobile IGIS is displayed in Figure 2. Logical architecture of mobile IGIS can be divided into 3 levels: framework services, user services and cloud services. Each of these levels contains different set of services that support functionality of the system as a whole. Cloud services are represented by a set of distributed servers, providing basic services for other units of the architecture. Cloud service level includes:

- modelling and mathematic models services – supports solution of special mathematical problems of mobile IGIS, such as maneuvering, calculation of vessels, route planning;
- external interaction server is intended for data exchange with exogenous systems and creates documents about current water situation;
- inference machine;

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- object server is assigned to support a unified object model of whole system. Main functions of the server are providing access to objects of subject area and operating them: adding objects to ontology of subject area, deleting objects, editing objects' properties;
- hydro-meteorological server provides automatic hydro-meteorological data receiving from different sources, storage and display of specific environmental parameters in given region;

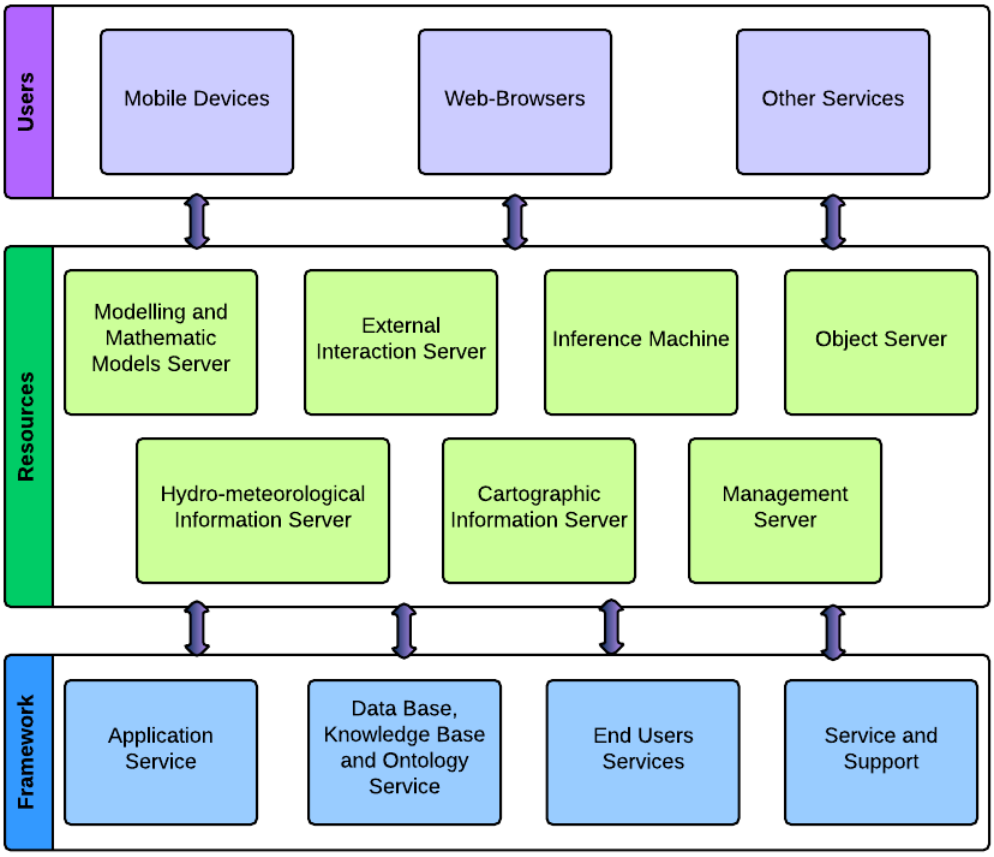

Fig. 2: Logical architecture of mobile IGIS

- cartographic information server realizes access to actual spatial data. Cartographic information server manages cartographic databases (data update, navigation, search and etc.) and batch transformation of cartographic data into given cartographic projection;
- management server supports distribution of resources, user access management, settings and operation control.

User services provide the necessary interface for connecting modules that implement required features and are installed on the mobile device. They provide access to cartographic, hydro-meteorological data, information about object's location and characteristics, and methods of mathematical modelling, allowing to solve maneuvering tasks and route planning tasks. Also, for experienced user special services are provided:

- creating and editing subject area (description of traffic infrastructure, description of city infrastructure) database (libraries, repositories);
- customization of special search engines.
- Framework services level includes the following services:
- application service;
- data base, knowledge base and ontology service;
- end users services;
- service and support.

Application service provides information and characteristics for organizing general work of applications in various layers (e.g. local network, global network).

Database is used for centralized storage, provision and selection of cartographic information. Knowledge base is designed to store techniques of solving tasks in given subject area. And ontology service represents a unified directory of data considering given subject area. Providing formulated data about concepts in knowledge domain and relations between them, it allows to sort data from exogenous sources as well.

5 CASE STUDY FOR SAFE NAVIGATION IN AMSTERDAM, NETHERLANDS

Suggested mobile IGIS allows users not only to determine their location based on GIS, GPS, AIS technologies, but to plot an optimal sailing route for their vessels, manage vessels' navigation, execute object search. Mobile GIS allows the user to solve following tasks.

5.1 Representation of main characteristics of sailing traffic participants

System's user can acquire information about water situation in any instant in any place in the world, according to data from AIS, radar, other users of mobile IGIS and other external sources of data. On the screen of mobile device main characteristics of the vessel are displayed: speed, course, vessel's category (passenger vessel, cargo vessel, yacht and etc.), and sailing route. Figure 3 demonstrates map on which the vessels' icons, it routes (blue line) and additional information are plotted.

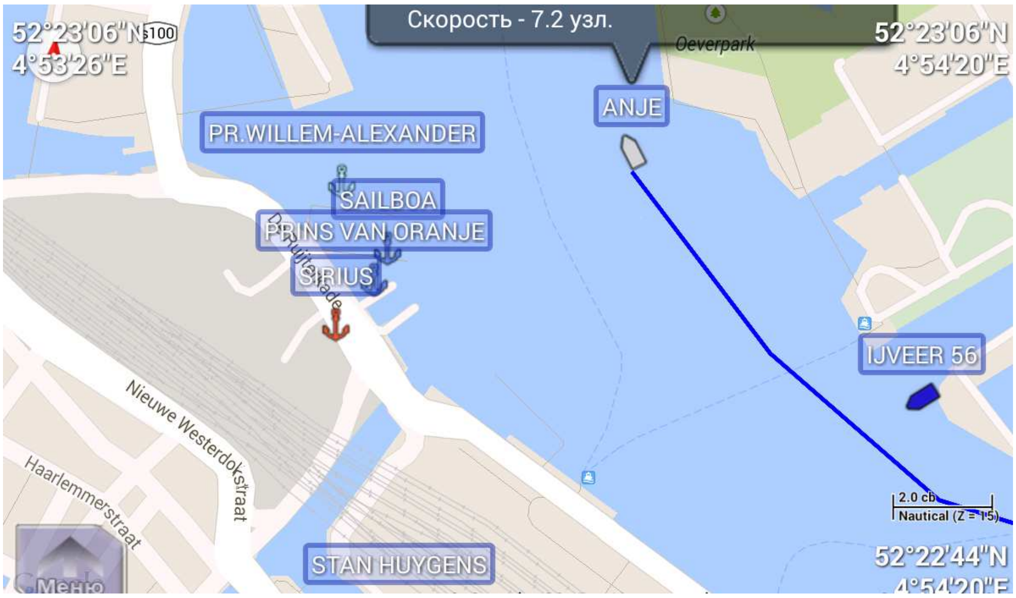

Fig. 3: Water traffic

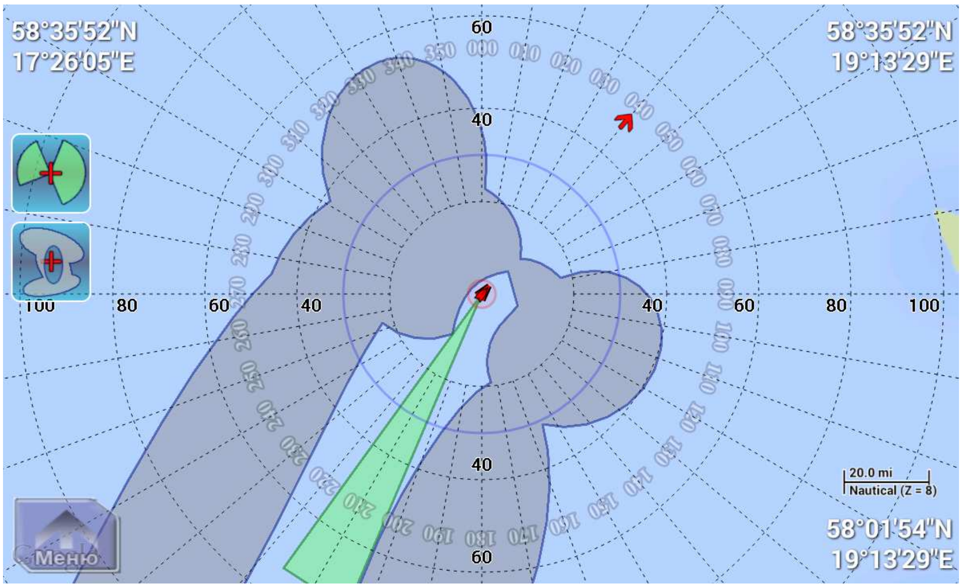

Fig. 4: Safe navigation on route

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5.2 Determination of vessels' sailing parameters

User is able to manually or automatically map sailing route's elements in the given city region, received from AIS and GPS. On device's screen sectors of recommended courses and speeds are displayed, providing safe navigation on route (in Fig. 4 are painted green), and also sectors dangerous for sailing (in Fig. 4 are painted grey).

5.3 Route plotting for vessels

Mobile IGIS allows the user to plan routes in automatic mode. While planning route, data about sailing distance for each course, sailing time, docks, gas stations and etc. is filled beforehand (Table 1). Recommended in this area routes and waterways, navigation reference points, duration of sailing and pit stops can also be marked on map.

Start point	Distance, m	Coordinates
1. Start: Hotel Plutzer Amsterdam	0	52.372837, 4.884232
2. Rijksmuseum	1730	52.360036, 4.884832
3. Museum Van Loon	890	52.363155, 4.892621
4. Hermitage Amsterdam	950	52.365343, 4.903093
5. Museum Het Rembrandtuis	640	52.369195, 4.901183
6. De Oude Kerk	1360	52.374252, 4.898184
7. Bloemenmarkt	1190	52.366777, 4.891447
8. End: Hotel Plutzer Amsterdam	1150	52.372837, 4.884232

Table 1: Route planning

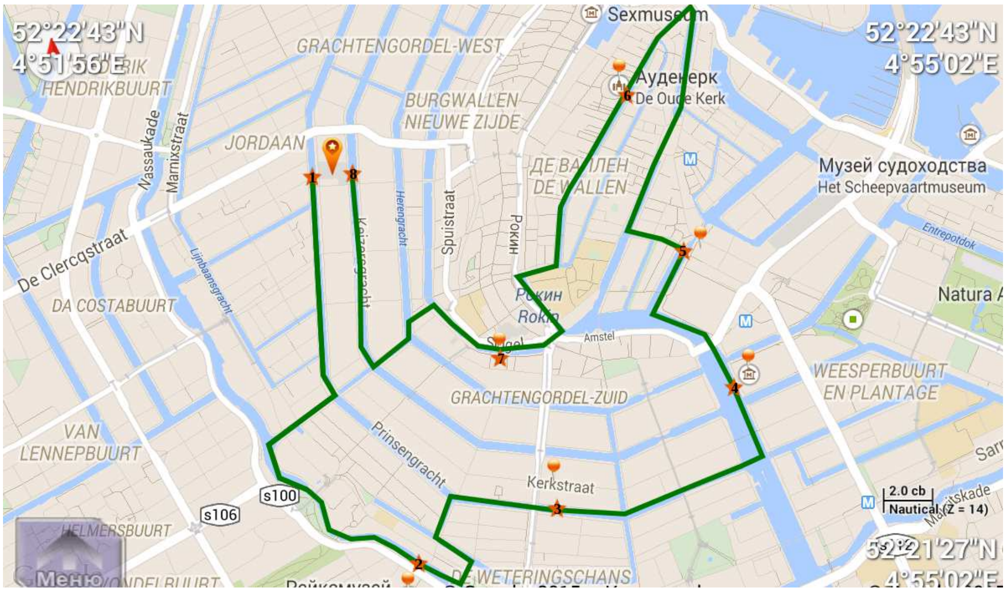

Fig. 5: Route planning

5.4 Representation and accounting of metadata

System provides display of actual and prognosed metadata (temperature, precipitations, atmospheric pressure) in given sailing region on electronic map.

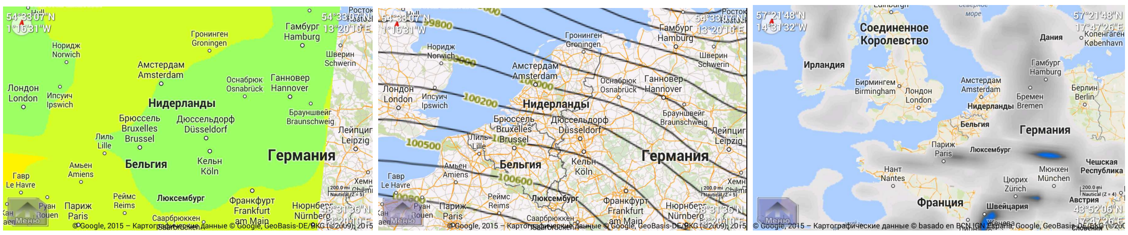

Fig. 6: Weather conditions

5.5 Notification about dangerous manoeuvres

While sailing in dangerous regions (sunken ships, dangerous climate conditions), shallow water regions or particular treatment regions (zones restricted for passenger vessels) system sends notifications to user.

6 CONCLUSION

At present, mobile GIS are one of the most perspective trends in development of geoinformation technologies. In this paper we have presented a concept of mobile intelligent geoinformation system oriented on providing means of safe navigation through city waterways. Usage of mobile IGIS will provide large city residents with opportunity to considerably simplify the process of navigating. Presented system allows to efficiently control water situation, plan sailing routes beforehand and safely navigate sailing city region.

In the future we plan to expand services and users' functions of mobile IGIS. We also plan to create an analogue of the application for small aviation and an application for disabled people.

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