

Bartosz Czaplewski*, **Krzysztof Cwalina****,
Sylwester Kaczmarek*, **Ryszard Katulski****

DATA VISUALIZATION OF MARINE OBJECTS ON DIGITAL MAPS

ABSTRACT

The paper presents the implementation of two multithreaded applications for data visualization of marine objects written in C#, designed to run on operator consoles with 32-bit or 64-bit Windows 7 OS. The article describes the most important functionality and features of the developed C# .NET user controls for data visualization on digital maps and in the configurable tables.

Key words:

data visualization, marine objects, digital maps.

INTRODUCTION

The aim of the KONSOLA project was to extend the Integrated Surveillance Radar System ZSRN (in Polish *zintegrowany system radarowego nadzoru*), which is currently used by the Border Guard, by the addition of the bidirectional data transmission and visualization of supervised objects on digital maps. The article describes a part of the achieved outcomes of this task, which is the dispatcher console software developed in the Gdańsk University of Technology.

* Gdańsk University of Technology Faculty of Electronics, Telecommunications and Informatics, Department of Teleinformation Networks, G. Narutowicza 11/12 Str., 80-233 Gdańsk, Poland; e-mail: {czapla; kasy1}@eti.pg.gda.pl

** Gdańsk University of Technology Faculty of Electronics, Telecommunications and Informatics, Department of Radiocommunication Systems and Networks, G. Narutowicza 11/12 Str., 80-233 Gdańsk, Poland; e-mail: {kkcwalina; rjkat}@eti.pg.gda.pl

The dispatcher application, written in C#, enables the use of radio communication, telephone, teleconference, Intercom, SMS, file transfer, and data visualization of marine objects. Data visualization on digital maps is available *via* MapControl, which is C# user control. Data browsing in graphical interface is available *via* BrowserControl, which is also C# user control. Both controls operate within the dispatcher application. The purpose of the produced software is an advanced visualization of the vessel traffic in the form of a configurable maps and database browser. The developed user controls, MapControl and BrowserControl, are designed to present both current and archival data.

Figures 1 and 2 shows the location of MapControl and BrowserControl in the overall structure of the software in the relationship, respectively, 'Mobile console — Universal radio controller' and 'Stationary console — Central server'. Stationary consoles communicate directly with the central database in the central server, i.e. in the supervision center CON (in Polish *Centralny Ośrodek Nadzoru*) and mobile consoles communicate directly with a local database in the universal radio controller URC (in Polish *uniwersalny sterownik radiowy*) or indirectly with the central database. The general principle of communication for both pairs 'console — database' is the same. In order to download the data, both controls always send requests to the map server which mediates in the communication with the database. The map server translates request messages to SQL commands and directs them to the local database in the case of mobile console, or to the central database in the case of stationary console. Once the data is obtained from the database, the map server sends replies to the MapControl or BrowserControl. An operator of a mobile console may want to download the data from the central database. In this case, the request is sent to the local map server which redirects the request to the central map server which retrieves the data from the central database and sends a response to the control *via* local map server.

Marine objects are visualized on maps based on data from AIS, ARPA and GPS devices as well as an external web service data stream. From the point of view of MapControl and BrowserControl, data from all sourced is stored in databases and transmitted to the consoles in the normalized form. In addition, the data in databases have been deduplicated, i.e. duplicates have been removed. More information on other elements of the KONSOLA system can be found in [2–4].

The second section describes the specification of the development environment of the MapControl and BrowserControl. The third section consists a description of the most important functionality of MapControl and BrowserControl. The summary of the article is in fourth section.

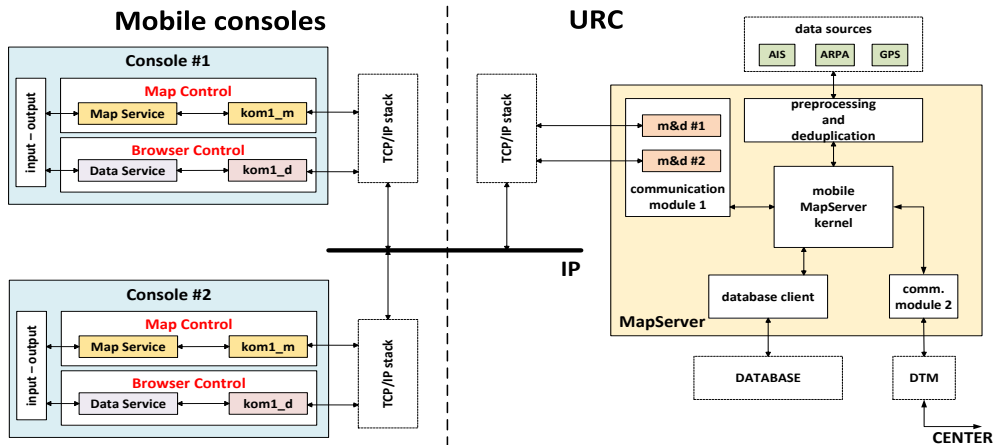


Fig. 1. The location of MapControl and BrowserControl in the structure of the software in relationship 'Mobile console — Universal radio controller (URC)' [2]

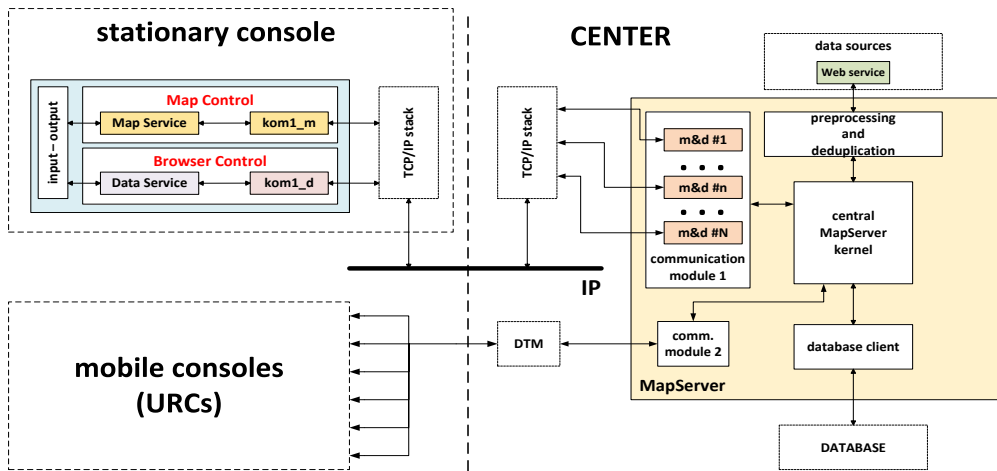


Fig. 2. The location of MapControl and BrowserControl in the structure of the software in relationship 'Stationary console — Central server' [2]

DEVELOPMENT ENVIRONMENT

MapControl and BrowserControl were written in C# .NET 4.0 framework and are designed to run on 32-bit Windows 7 OS. However, they can be used also in 64-bit architecture and in newer Microsoft Windows operating systems, such as Windows 8 and 8.1. Both applications were programmed in the Microsoft Visual Studio environment.

Rendering of digital maps in MapControl has been realized using TatumGIS map engine [5]. TatumGIS Developer Kernel .NET Edition is enabling the development of customized standalone applications for visualization of geographic data. In addition, the user license allows the use of various graphical elements of the library throughout the application.

MapControl and BrowserControl have been developed as C# user controls, i.e. autonomous controls that can be imported to the programming software or be added to references of any WinForms application project. In both cases, they become integral part of the development environment and they are handled in the same manner as basic C# controls.

FUNCTIONALITY

During its operation, MapControl consists three threads: main thread and two communication threads, i.e. transmitter thread and receiver thread, which both are using AMQP protocol [1]. The main thread is responsible for map rendering, handling graphical user interface, forming request messages to the database analyzing replies messages from the database. The task of the transmitter thread is to send the requests to the map server. The task of the receiver thread is to receive the replies from the map server. Figure 3 shows an example of data visualization of marine objects on digital maps using MapControl. The list of the most important features of MapControl is as follows:

- rendering of digital maps in various formats (optimized for S-57 maps);
- selection of any geographic coordinate system by EPSG code;
- presentation of geographical coordinates in DMS format (Degrees-Minutes-Seconds) and DD (Decimal Degrees);
- adding and removing maps during the operation;
- filtering of displayed layers and sub-layers of digital maps;
- moving the visible area by buttons or by dragging on the screen;
- centering of the view on set geographic coordinates;
- centering of the view on geographical coordinates of the URC;
- centering of the view on the object selected in BrowserControl;
- zooming in and out by using buttons, dragging on the screen or selecting fragment of the map to zoom;
- visualization of the current situation on the map *via* graphical symbols and text labels for marine objects;

- presentation of objects' course through displaying normalized course vectors or rotating the outlines of vessels in accordance with their course;
- extensive filtering of displayed symbols and labels;
- presentation of detailed information about the selected object;
- tracking the selected object on the map;
- presentation of routes traveled by the objects;
- three color variants for map, symbols and labels: day, night and twilight;
- presentation of the current local time and UTC;
- visualization of the archival situation on the map *via* graphical symbols and text labels for marine objects;
- selectable playback speed of the archival situation on the map;
- data download from the central database for visualization on the mobile console;
- saving operator's settings to a configuration file.

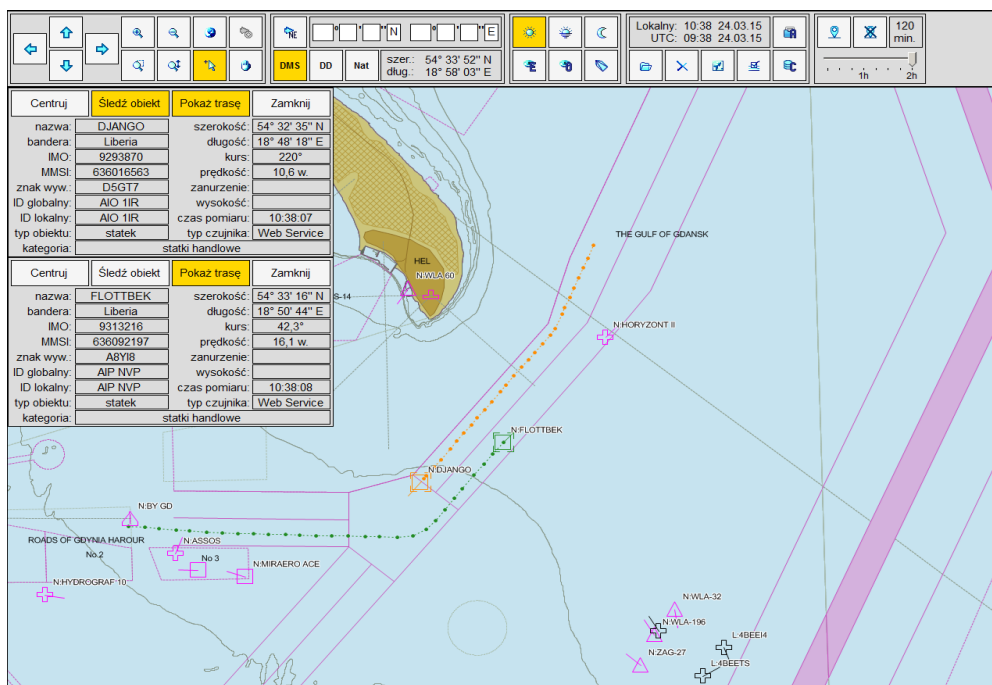


Fig. 3. Example of data visualization of marine objects on digital maps using MapControl

During BrowserControl operation three threads are created and executed: the main thread and two communication threads, i.e. transmitter thread and receiver thread, using AMQP protocol [1]. The main thread has the task, among others, forming

request database messages to be sent by the transmitter communication thread, implementation and maintenance of graphical user interface. Transmitter thread sends request messages to the map server software while receiver thread receives and interprets the response messages from the map server and update graphical user interface. Both communication threads work on the basis of a thread-safe FIFO (First In, First Out) queue. In figure 4 an example of the database lookup for marine facilities in BrowserControl application is presented. The list of major functions performed by BrowserControl software is given below:

- display and view the current list of objects;
- interpretation of data, including MMSI number, flag, navigational status;
- retrieve data from local and central database;
- interruption of processing the data for the replies from the central database;
- display data from various sources (AIS, ARPA, GPS and other);
- sort data by a particular column (descending/ascending);
- automatic refresh of the current list of objects;
- dynamic search on the table — search algorithm is activated each time when searched phrase changed;
- accurate search data in a table based on selected criteria;
- display the total number of marine facilities;
- display the selected object from the list on the map in the MapControl;
- display text notes from the selected period;
- view the notes information, including author entry, the date of the entry;
- adding notes to the selected object;
- interface for ease checking the archive entries currently displayed object in the list of current facilities;
- retrieve the selected object archive data, indicating the interval and the maximum number of position entries within the selected period;
- two modes of display colors: day and night;
- choice of the displayed data for the current and archival list of objects;
- automatic adjustment of all elements of the graphical user interface to control the dimensions selected by the user in the so-called edit mode;
- possibility of activation tips for novice users;
- read/write user settings to/from the configuration file.

Both applications: MapControl and BrowserControl store operator status in the configuration file whose name and path results from the data provided by the relevant public methods of control. The configuration file for MapControl contains

the most recently used: geographic coordinate system, the format of presentation of geographical coordinates, recently viewed coordinates, color variant, map operation mode, flags of binary filtering symbols and labels of objects, showing outlines of ships, the length of traveled routes, communication configuration parameters with database, the path to recently used maps, size and location of control in the container. The configuration file for BrowserControl includes, among others, communication parameters, unique ID and the name of the logged-on operator, a string of binary flags interpreted as a set of visible and hidden data in the columns and the time of automatically refresh list of objects.

ID globalny	ID lokalny	ID jednostki SG	Czas utworzenia	Czas ostatniego zapisu	Czas pomiaru	Typ obiektu	Kategoria obiektu	Bandera	MMSI	Numer IMO
4BE FT2	4BE FT2	123	2015-03-10 16:15:17	2015-03-24 10:47:07	2015-03-24 10:46:47	statek	kategoria nieznaną	261 Polska	261027110	brak informacji
4BE GMC	4BE GMC	123	2015-03-24 10:10:26	2015-03-24 10:47:07	2015-03-24 10:46:47	statek	statki rybackie	261 Polska	261010020	brak informacji
4BE 7GI	4BE 7GI	123	2015-03-10 16:15:22	2015-03-24 10:47:07	2015-03-24 10:46:47	statek	kategoria nieznaną	261 Polska	261003330	9240354
4BO ZBK	4BO ZBK	123	2015-03-11 14:11:19	2015-03-24 10:47:07	2015-03-24 10:46:47	SAR	kategoria nieznaną	261 Polska	261506000	brak informacji
4BE EI4	4BE EI4	123	2015-03-17 09:43:44	2015-03-24 10:47:06	2015-03-24 10:46:46	statek	kategoria nieznaną	0 niezidentyfikowana		brak informacji
AIO 1IR	AIO 1IR	123	2015-03-24 10:10:26	2015-03-24 10:47:07	2015-03-24 10:46:46	statek	statki handlowe	636 Liberia	636016563	9293870
4BO GSW	4BO GSW	123	2015-03-10 16:15:03	2015-03-24 10:47:06	2015-03-24 10:46:46	statek	kategoria nieznaną	261 Polska	261482000	9477048
4BE DB2	4BE DB2	123	2015-03-10 16:15:34	2015-03-24 10:47:06	2015-03-24 10:46:46	statek	kategoria nieznaną	261 Polska	261010910	brak informacji
4BI AKW	4BI AKW	123	2015-03-12 13:40:18	2015-03-24 10:47:05	2015-03-24 10:46:45	statek	kategoria nieznaną	261 Polska	261194000	8030908
4EG ZGB	4EG ZGB	123	2015-03-24 10:10:45	2015-03-24 10:47:05	2015-03-24 10:46:45	statek	kategoria nieznaną	266 Szwecja	266129000	9271896
4BE BT4	4BE BT4	123	2015-03-10 16:15:14	2015-03-24 10:47:06	2015-03-24 10:46:45	statek	statki rybackie	261 Polska	261005080	brak informacji
4BE AYC	4BE AYC	123	2015-03-11 14:11:20	2015-03-24 10:47:06	2015-03-24 10:46:45	statek	statki rybackie	261 Polska	261007860	brak informacji
01K 11W	01K 11W	123	2015-03-10 16:15:39	2015-03-24 10:47:05	2015-03-24 10:46:45	stacja bazowa	kategoria nieznaną	261 Polska	2614100	brak informacji
4BE 4ZW	4BE 4ZW	123	2015-03-11 14:12:06	2015-03-24 10:47:04	2015-03-24 10:46:44	statek	kategoria nieznaną	261 Polska	261000140	9101194
4BE SGO	4BE SGO	123	2015-03-12 13:10:24	2015-03-24 10:47:04	2015-03-24 10:46:44	statek	statki rybackie	261 Polska	261000720	brak informacji
4BI LDS	4BI LDS	123	2015-03-10 16:15:18	2015-03-24 10:47:03	2015-03-24 10:46:43	statek	kategoria nieznaną	261 Polska	261208000	9231925
4BI 4LN	4BI 4LN	123	2015-03-11 14:11:18	2015-03-24 10:47:03	2015-03-24 10:46:43	statek	kategoria nieznaną	261 Polska	261186251	brak informacji
557 1YS	557 1YS	123	2015-03-13 14:05:48	2015-03-24 10:47:07	2015-03-24 10:46:43	statek	statki pasażerskie i promy	311 Bahama	311058100	7907661
4BE 9K2	4BE 9K2	123	2015-03-12 13:09:00	2015-03-24 10:47:03	2015-03-24 10:46:42	statek	statki rybackie	261 Polska	261006050	brak informacji

Fig. 4. Example of database browsing in the table using BrowserControl

SUMMARY

This paper contain a functional description of developed controls MapControl and BrowserControl operating in the parent application in operator consoles with the task of marine facilities data visualization and browse databases in the form of configurable tables. The data from the AIS, ARPA radars, GPS devices and external

data stream WebService from the Centre are interpreted and presented to the user in a standardized form with the ability to select the level of detail.

Presented applications should be treated as components of a larger software structure 'Mobile Console — URC' or 'Stationary Console — Central server', which act as terminal in the KONSOLA project. Controls are not stand-alone applications and require proper operation of the whole system in order to perform the functionality described in the paper. Implemented modular structure enables scaling the software and its eventual expansion for further functions.

MapControl using TatukGIS engine visualizes data of marine facilities on digital map and allows, inter alia, to visualize the current situation at sea, displays basic information about the selected objects, object tracking, presentation of routes traveled by the objects and view archival situation on the map for a given date and time.

BrowserControl is designed to present to the user a wider range of data of current and archival marine facilities. Viewing data has been facilitated by the configurable data display, search and sort the displayed records without having to re-download data from local or central database.

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WIZUALIZACJA DANYCH O OBIEKTACH MORSKICH NA MAPACH CYFROWYCH

STRESZCZENIE

W artykule przedstawiono realizację dwóch wielowątkowych aplikacji wizualizacji danych o obiektach morskich napisanych w języku C# przeznaczonych do uruchamiania w 32-bitowym systemie operacyjnym Windows 7 lub nowszym na konsolach operatorskich. Opisano najistotniejsze funkcjonalności oraz cechy opracowanych kontrolki do wizualizacji danych o obiektach morskich na mapach cyfrowych oraz w postaci konfigurowalnych tabel.

Słowa kluczowe:

wizualizacja danych, obiekty morskie, mapy cyfrowe.