

GeoLocSI – Web-Based GIS for Verification and Modification of Data Stored in Data Base

Spatial Data Presentation and Modification Through Web-Based Geographical Information System

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Abstract—Currently there are thousand container events happening daily on more than 20 000 locations in the World. Some of these locations are big international ports and others are just little cities with not precise coordinates in the free available Data Bases (DB). Verification and validation these locations are at the same time a very important task and a challenging one. This paper describes the development of a web-based geographical information system for assisting in verifying and modifying geographical data in DB by interactive intuitive GIS technique. For the proper work of the system, first we collected geographical data for container ports from different open sources according to the known container ports' names from our ConTraffic System. Then we stored it in a dataset in our DB and we created a map-based application which allows us to see not only the data in tabular view but also the geographical position of the ports over a map. Using this web-based application all the data can be modified quite easy, including the geographical coordinates. They can be modified directly by just typing the correct coordinates or by interactive way (drag the graphical object to the correct geographical position on the map).

Keywords-component; *Geographical Information Systems, Geographical coordinates, GIS assistance, Web-based interface for data modifications in Oracle, Container Ports, Web service, Human Computer Interface*

I. INTRODUCTION

Around 90% of the non-bulk cargo is transported in containers travelling by sea [1]; that is an estimated number of about 18 millions of containers per year. Only 2% of them are physically inspected by Customs Authorities [2]. This makes shipping containers a security breach in the supply chain, paving the ground to their usage in a number of illicit activities, including commercial frauds, illegal traffic, and even terroristic attacks.

In some recent studies [3, 4, 5] several researchers try to create new methods for analyzing itineraries of vessels and containers and providing computed artificial assistance for detection of anomalous itineraries. Such assistance will help the maritime authorities providing control of containers and it

will allow them to focus better on the suspicious containers or vessels.

An essential part of itinerary analysis for anomaly detection is the visualization and interaction techniques. They are widely recognized to be very powerful in maritime domain and may close the gap between the domain experts and the data mining engines [6]. Furthermore, visualization methods take advantage of human abilities to perceive patterns and to interpret them, which can be critical in complex situations, especially when the dataset is multi-dimensional, massive and dynamic. The experience shows that when the dataset is really huge, it is particularly difficult to assess what kind of data drilling techniques could be used for transforming the data. In such cases, the visualization of the data could help significantly by giving an initial general geographical view of the object's behavior. In certain cases, it can also indicate abnormal movements, i.e. movements in circles, unnecessary transshipments and other.

For realization of such geographical visualization for container movements, we need not only itinerary information but also geographical data about the locations. Currently, we have registered container events in our Data Base (DB) at more than 20 000 locations in the entire world. Some of these locations are big international ports and others are just little cities or villages. As Maria Riviero says, "In today's information age, the lack of information is seldom a problem", but today there are other actual problems, such as "difficulty of processing and handling vast amounts of information from many and different sources" [7], information fusion, accuracy and verification of the information and other. In the current paper, we raise a problem on which we come across during the development of web-based geographical visualization of container movements. This problem is the accuracy of the geographical coordinates collected from different sources. It is crucial for the utility of any geographical visualization (including the one for container movements). For this reason we conceived implemented and tested a solution for the verification of data collected and stored in the ConTraffic DB. Our solution, which helped us to solve the problem, is an

interactive web-based GIS system for verification and modification of the geographical data in Oracle DB.

The paper is organized as follows: Section 2 gives an overview of ConTraffic system and DB. Section 3 gives a description of the available free open spatial databases and the encountered problems with the spatial data accuracy. In following section we propose our solution for verification and modification of the spatial data in Oracle DB. Finally, in the last section, we conclude the paper with a discussion of the contributions of our approach, its advantages and limitations, the achieved results from the implementation of the prototype and the future improvements.

II. CONTRAFFIC SYSTEM AND DB

ConTraffic system illustrated in Fig.1 gathers data on container movement from a number of on-line open source repositories. The data are collected in terms of little pieces of information, called “Container Status Messages” (CSM). Each CSM presents a single event or status of a container. The format is semi-structured and describes the performed actions or the status of the containers. Currently the ConTraffic database contains more than 1 billion CSM records making the both tasks of analysis and visualization quite challenging.

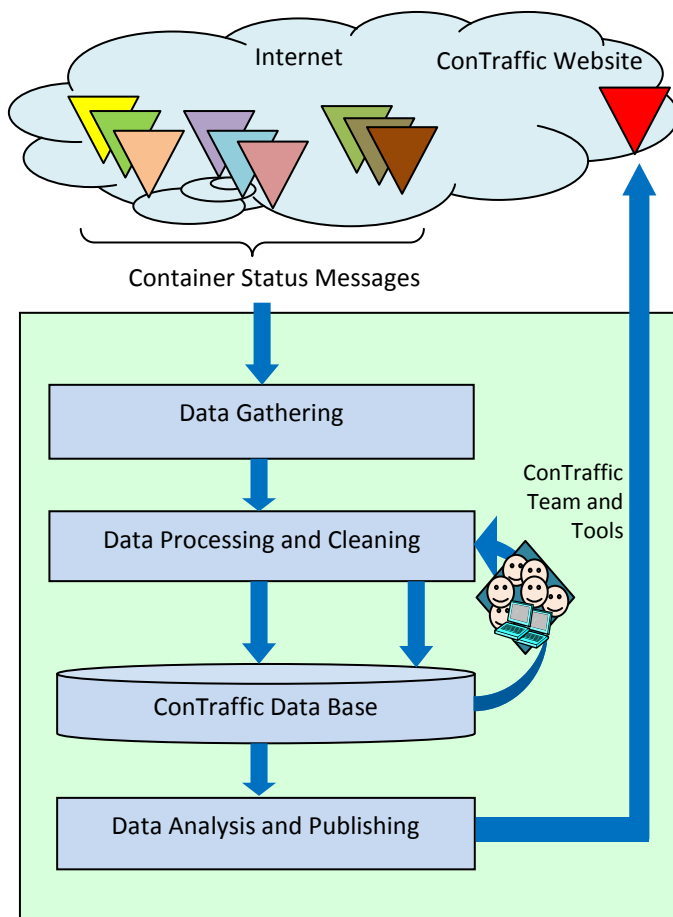


Figure 1. Overview of the ConTraffic system.

Every CSM includes:

- 1) Container identifier as assigned by the Bureau International des Containers et du Transport Intermodal [8, 9]. It is composed by: a code for the owner of the container; a code for the category of container; a serial number of the container; and a check digit.
- 2) Text description of the geographical location (called **unclean location**); the location described is usually a port, where the event took place. The text string may contain the name of a city, port, the name of a station/airport, the name of a country, or even detailed port or terminal codes. During the pre-processing stage, named automatic-location cleaning, a match between this string and **standard location** in the ConTraffic database is searched. The dataset of standard locations is built mainly using the UN/LOCODE (United Nations Code for Trade and Transport Locations) dataset, which is open source and it is provided by the United Nations Economic Commission for Europe [10]. Each record contains the location name, UN/LOCODE location code, country name, a UN/LOCODE unique country code, subdivision, status of the record, functions of the location (port, rail station, airport, etc.), geographical coordinates, etc. In case of a match, the text description is assigned to the unique identifier of the matched record. In this case we say that the text description of the location has been **cleaned**.
- 3) Text description of the event occurring to the container and load status.
- 4) Date and time when the event occurred.
- 5) Additional details, if such are available; for instance vessel name, voyage identity number, etc.

Since the CSMs are text messages gathered from multiple and heterogeneous data sources, the data are imprecise and ambiguous [11] and there are several challenges in interpreting and integrating the data. Furthermore, the data are sometimes not complete and it may even contain errors. Moreover, the data are semi-structured, which means that the information is not following any standardized data format. The problem of data interpretation and integration is particularly difficult for the text description of the locations. The automated location cleaning procedure described above cannot cover all the cases and manual intervention is constantly needed. To assist the manual operations we have developed dedicated application GeoLocSI which is a web-based GIS application used for verification and modification of location data in the ConTraffic DB. The design and the implementation of ConTrafficGeo are described in the next sections.

III. ACCURACY OF SPATIAL DATA AND FREE AVAILABLE DB

Essential part of any geographical visualization is the accuracy of the used geospatial data. If the quality of this data (accuracy, completeness, and updates) is not at high level, it can impact the visual outcome and the validity of the final decision. Therefore, the usefulness and the significance of the visualization depend strongly from all accuracy of the data. That is the reason why, in every GIS implementation the data

needs to be cross-checked and carefully examined before using it for any decision making activities. Verification of the accuracy of the geospatial data are especially crucial when the data are huge and gathered from many different origins which use different data formats, as it is in our case.

Then the following question appears - how we can estimate the **accuracy** of the huge geospatial data? Rodric Ericson [12] already studied the accuracy of the geospatial data. He described it in terms of spatial (positional) accuracy for the future mapped and completeness (content) accuracy of the attributes. The spatial accuracy is defined as the positional accuracy of the features in the geospatial data as measured horizontally and vertically. Spatial accuracy tells us that when we see a feature on the map, there is known probable location within certain limits and diversion from the precise geographical position on the map (example can be seen in Fig.2 for a location with name Anguilla, with geographical coordinates gathered from free online source and which are quite far from the real position of the island Anguilla).

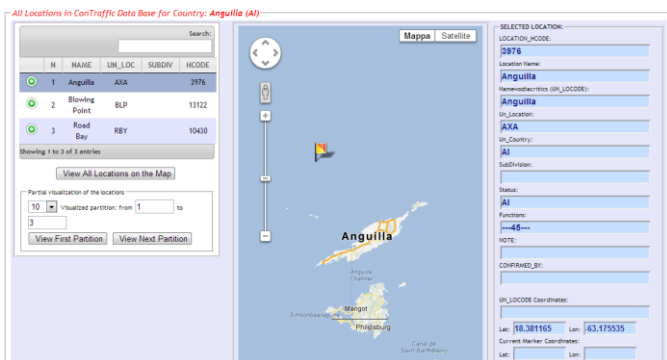


Figure 2. Low spatial positional accuracy.

The content accuracy can be defined as content or accuracy of attributes of the geospatial data. According to Rodric Ericson [12] important factor for the content accuracy is the lineage which is related to knowing where the data came from, how was it developed, how old are the data, in what format was stored the data, etc. That's why we decided to form our new dataset based mostly on the dataset UN/LOCODE, which is provided and approved by United Nations Economic Commission for Europe (UNECE). This dataset contains detailed information about 91,143 (in its last version from 7/03/2013) geographical locations used in trade and transport with functions, such as seaports, rail and road terminals, airports, post offices and border crossing points. The data are supported by the alpha-1 country code of the last issue of ISO 3166-1 [6]. The location codes and subdivisions are those included in ISO 3166-2 [8]. The table UN/LOCODE is with free open access and its last version can be downloaded from the official website of UNECE in several formats (html, mdb, csv and txt).

To be noted that 62,443 locations have geographical coordinates and the rest 28 700 locations of this data source don't have coordinates. Unfortunately, we found out also that

big number of locations (10,984) from our dataset (20,405 locations used as container ports) don't have geographical coordinates in UN/LOCODE dataset, so for these locations we needed to rely on another dataset with spatial data, such as World Port Index, GeoNames or using some free online web-services providing us geographical geocoding.

The World Port Index is a free available dataset provided by the National Geospatial Intelligence Agency. It contains information about 3,700 international ports, including physical characteristics, facilities and services, terminals, coordinates and other [13]. The geographical coordinates are given in a format similar to the format used by UNECE.

The GeoNames is another geographical dataset [14] which contains information about over 10 million geographical objects and over 8 million unique features. All features are categorized into one out of nine feature classes and further subcategorized into one out of 645 feature codes. The data are accessible free of charge through a number of web services and a daily database export. The dataset contains information about the names of the places in various languages, elevation, population and others. All geographical coordinates are given in WGS84 (World Geodetic System 1984).

Some websites offer geocoding. This is a web service for automatic association of textual description of location with a real geographical location with geographical coordinates from some geographic dataset. The textual description could include the location name, street addresses, country name/code, ZIP codes (postal codes) and other. Such kind of service is provided by free accessible website (<http://www.gpsvisualizer.com/>) where geocoding is possible to be performed according to Google or Yahoo dataset. The service was selected because the special featured available (possibility to select different data sources and comparison of the results), well known accuracy performance of the Google data base and ease of use.

More details about the collection of geographical coordinates can be found in a technical report [15]. In the same report several problems are described, occurred during the exploring of the mentioned datasets. Because of these problems, during the collection of coordinates for locations without UN/LOCODE coordinates, we decided to rely mainly on the geocoding (where it was possible to compare the coordinates received from Google and Yahoo source) and use the mentioned datasets only for single locations.

Since the decimal format of presenting the geographical coordinates (gathered by geocoding) could give high precision, we decided to store our coordinates in this format, so we transformed the geographical coordinates from UN/LOCODE dataset to decimal format. The transformation was performed by a PHP program which follows the algorithms presented in Fig.3.

The model of UN/LOCODE coordinates can be presented in the following way: "XXxxA YYYyyB", where "X" and "Y" are digits $\in \{0, 1, 2, 3, 4, 5, 6, 7, 8, 9\}$ and present the decimal values of the latitude and longitude. "A" and "B" are letters which present the geographical direction. Only one direction is

allowed for latitude and longitude, with other words $A \in \{S, N\}$ and $B \in \{W, E\}$, so only “S” or “N” is possible for latitude and only “W” or “E” for longitude.

In order to guarantee the data quality some control procedures (implemented in PHP) are executed. Their objectives are, as follow:

- control of the right format of the UN/LOCODE coordinates - “XXxxA YYYyyB”;
- control for values of the coordinates outside the possible range: for latitude: [-90; 90] and for longitude: [-180; 180];
- control for zero values of the coordinates.

During these control procedures we found out some inaccuracy in the geographical coordinates. The first one was zero coordinates for several locations (Fig.4). For these locations we found the correct coordinates in other datasets and we corrected them manually.

Visayas, country: Philippines) is 9.25 for latitude and 123.2666667 for longitude. If we make the reverse transformation of these coordinates, we would receive: N09° 15.0', E123° 16.0, and if we present this in in UN/LOCODE model, it would be “0914N 12318E”. Therefore, the first zero was missed and unnecessary empty space was added between the digits of the latitude.

GA	GIM	Miele Mimbale	Miele Mimbale	RQ	---4---	0901	0001S 01123E	
LK	WLP	Wellampitiya	Wellampitiya	RQ	----6--	1007	0000N 00000E	
MX	SFJ	San Francisco J	San Francisco J	COL	RL	--3----	0901	0000N 00000E
TF	PFR	Port-aux-Franç	Port-aux-Franc	RL	1-3----	0601	4921S 07013E	
GA	GIM	Miele Mimbale	Miele Mimbale	RQ	---4---	0901	0001S 01123E	
LK	WLP	Wellampitiya	Wellampitiya	RQ	----6--	1007	0000N 00000E	
MX	SFJ	San Francisco J	San Francisco J	COL	RL	--3----	0901	0000N 00000E
TF	PFR	Port-aux-Franç	Port-aux-Franc	RL	1-3----	0601	4921S 07013E	

Figure 4. Zero coordinates.

Several locations were found with geographical coordinates out of the possible ranges. For all these locations we used another dataset to find the correct coordinates.

Country	Location	Name	NameWoDi:	Subdivision	Status	Function	Coordinates
IN	ITA	Itanagar	Itanagar	AR	RL	--3----	9706N 09337E
PH	BAC	Bacong	Bacong	NER	RQ	1-----	9 14N 12318E
AQ	AMS	Amundsen-Scc	Amundsen-Scc		RL	--3----	8959S 13916E

Figure 5. Wrong UN/LOCODE format.

During the exploration of the collected geographical coordinates we realized the existence of another problem in the spatial accuracy. It comes from the used UN/LOCODE format which doesn't allow high precision of the geographical coordinates. We realized this fact when we transformed the collected geographical coordinates (gathered in decimal format) to UN/LOCODE format and later we transformed them back again to decimal coordinates. During this transformation the fractional part of the decimal coordinates is rounded (cut and lost) and it reflects to a diversion of the coordinates. The visualization of the coordinates before and after transformation shows significant distance between the both geographical positions.

As Rodric Ericson [12] tells the “testing of the spatial and content accuracy of the data serves to protect the end user and all decisions based on that data”. So, once we collected all necessary coordinates we needed of some interactive method for verification of this spatial data before using it in the application for geographical visualization of container movements which will be used for decision making by authorities providing maritime control. The basic requirements were interactive geographical visualization of the data stored in our Oracle DB and possibility for interactive modification of the data. Recently, many studies speak about an integration of web services with GIS which allows development of different tools for assistance of decision makers during the observing spatial related data. Several studies [16-21] describe different ways for realization of such systems calling them web-based geographical information systems. For their realization different languages and databases are used as PHP,

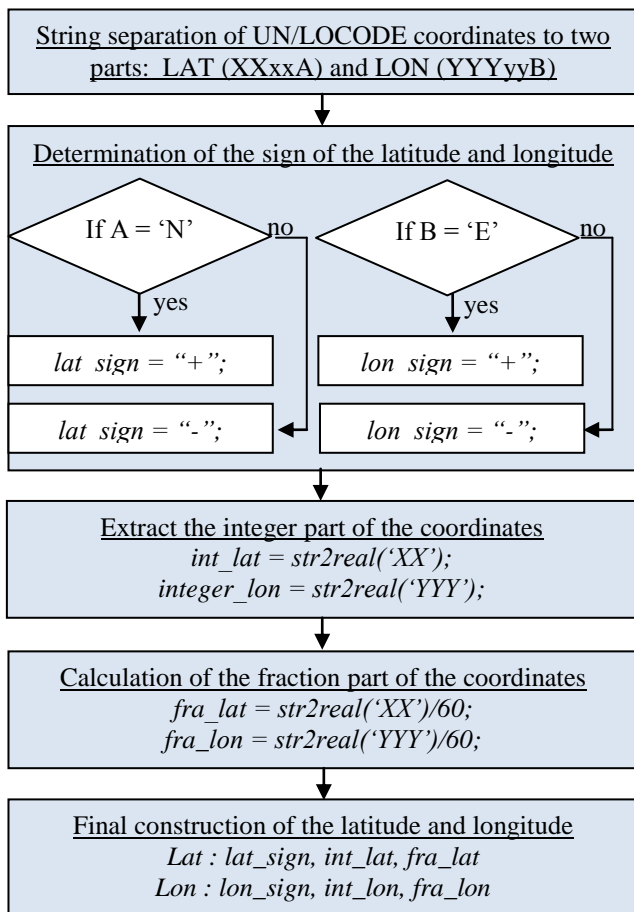


Figure 3. Algorithm for transformation of UN/LOCODE coordinates to decimal coordinates.

Another inaccuracy for other locations, which we found, is probably a result from syntax typing error. For example, location with name “Bacong” has coordinates which have an empty space inside the number presenting the latitude: “9 14N 12318E” (Fig.5). Using geocoding we found out that the coordinates of this location (Bacong, Philippines, city: Bacong, county/district: Negros Oriental, state/province: Central

JavaScript, HTML, MySQL, Oracle, etc. Many of them use free web mapping services as Google Maps [16, 17] Microsoft Virtual Earth, Yahoo, OpenStreetMaps. Most of these systems are used only for presentation of collected spatial data (retrieval of maps and map-related data) and assistance support to the decision makers, as Toshima says “a web server provides information to the client, but the client cannot feeds information back to the server” [22]. Nevertheless, for solving our problem, we needed not only server-client directed connection but also client-server directed connection; with other words, we needed web-based GIS which can send data to the server which will store the received data from the client directly in the DB. In the next section we propose a prototype of web-based geographical information system that allows user to query, review and modify the geographical data from a standard web browser.

IV. GEOLOC SI – WEB-BASED SOLUTION FOR VERIFICATION AND MODIFICATION OF THE GEOGRAPHICAL DATA

For the development of our prototype we used the following programming languages: PHP (for dynamical part of the webpages), html (for the static part of the webpages), JavaScript (for providing user interactivity), SQL (for creation and execution of request to the Oracle DB), Google Maps API (for mapping and handle the mouse events) and DataTable Plug-In for JQuery library (for tabular presentation of the data). A scheme of the GeoLocSI architecture [23] can be seen in Fig.6.

The collected set of locations with geographical coordinates is stored in a table “gis_locations” in our Oracle DB. The modification of the data is allowed only for some registered users, whose usernames and passwords are stored in “geolocsi_users” table.

The main source of the application is in “GeoLocSI.php” file. It is responsible for initial loading of the application and visualization of any user requested information. This file uses two assistance files – “db_connect.php” and “db_update.php”. All necessary data for connection to the Oracle DB (username, password, sid, address, etc) are stored in “db_connect.php”. The “db_update.php” is called when some data need to be send to the server and stored in the DB. In that case, the GeoLocSI calls “db_update.php” with specific input parameters (which contains the user identification information and the new data which must be stored).

The main screen of the prototype can be seen in Fig.7. The verification of the location is performed based on selected country. After selection of the country, the “GeoLocSi.php” is reloaded and the PHP part of the file creates and executes a SQL request to ConTraffic DB for extraction of all location in the selected country. The data are stored in PHP Array and later transformed by JSON to JavaScript array, which is used for visualization of the data in an interactive table (location list – Fig.8) and providing the interactivity of the geographical visualization. The JSON (JavaScript Object Notation) is a text-based open standard designed for human-readable data

interchange. It is derived from the JavaScript scripting language for representing simple data structures and associative arrays, called objects. Despite its relationship to JavaScript, it is language-independent, with parsers available for many languages, which makes it suitable for easy passing objects and arrays between PHP and JavaScript language.

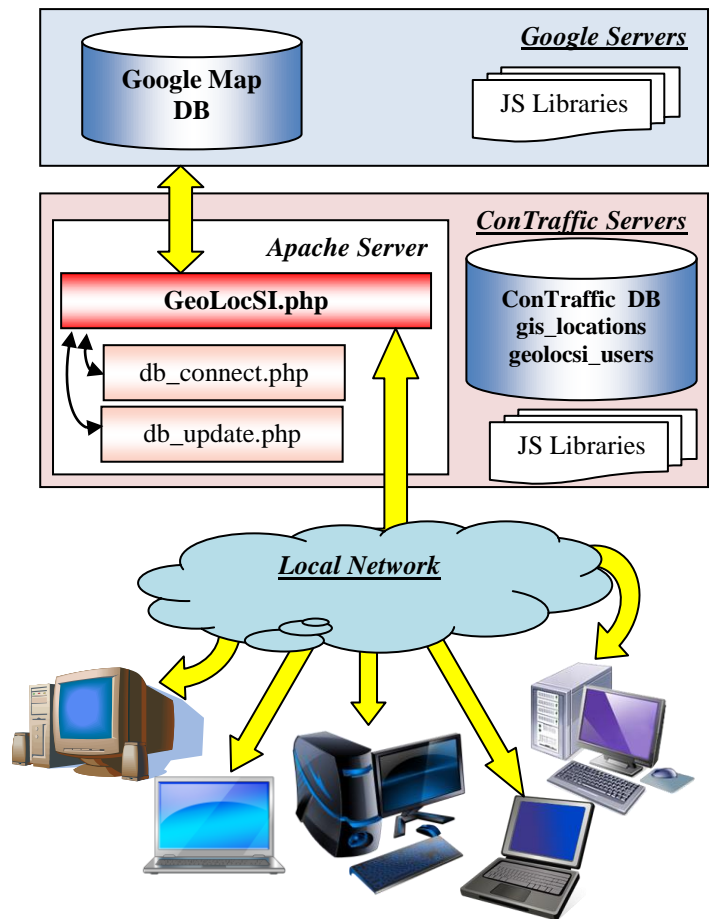


Figure 6. GeoLocSI Architecture.

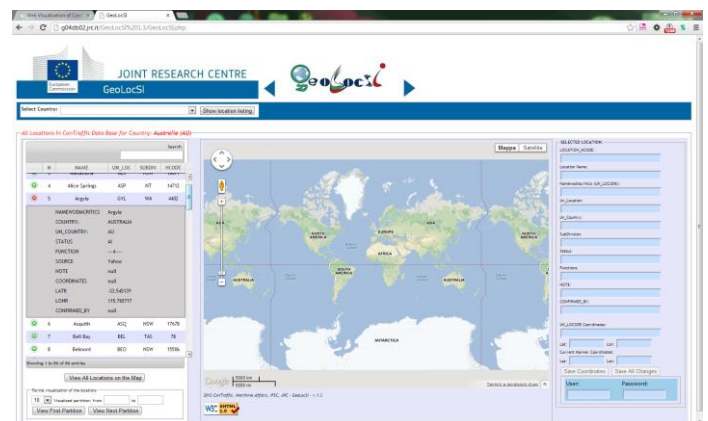


Figure 7. Main screen of GeoLocSI.

Relying to the library DataTable, it was possible to provide some interactivity for the location list (for example click over “green plus” shows extra info for each location, search text string in the location names, etc.).

Once the user loads the locations for some country, he can see the geographical visualization of the positions of all locations, partition of the locations (10, 20, 50 or 100) or just a single location. The geographical visualization is realized over a Google map by Google Maps API. The Google Maps API is collection of APIs that enable the user to overlay his own data on a customized Google Map. The advantages of using Google Maps are well-known; some of them are: supply of different map views which can be selected by the final user, simplicity of the maps, zoom features, good documented functions for programmer, quite easy adding of different overlays (markers, lines, polylines, graphical objects, etc.) over the map and many other possibilities.

Each location is presented by a blue icon with a number corresponding to the sequence number of the location in the location list. This visualization helped us to determinate very fast locations with suspicious coordinates which were stated at very distant from the borders of the country (Fig.9 present a case for country Albania and distant location stated in Africa).

panel and a flag-icon (Fig.11) shows the geographical position of this location over the map according to the current geographical coordinates in our DB. All the textual data can be modified by the user just by editing the corresponding fields in the right panel.



Figure 9. Suspicious coordinates of a location.

Search:				
N	NAME	UN_LOC	SUBDIV	HCODE
3	Balchik	BAL		19348
4	Blagoevgrad	BLN		20809
NAMEWODIACRITICS		Blagoevgrad		
COUNTRY:		BULGARIA		
UN_COUNTRY:		BG		
STATUS		RL		
FUNCTION		--3-----		
SOURCE		UNECE		
NOTE		null		
COORDINATES		4201N 02306E		
LATR		42.01666667		
LONR		23.1		
CONFIRMED_BY		null		
5	Botevgrad	BRF		15229
6	Burgas	BOJ		6870
7	Byala	BYL	03	17876

Showing 1 to 47 of 47 entries

Figure 8. Location List

JavaScript applets allowed us to give interactivity to the icons as well – any mouse click over some icon shows detailed information about the corresponding location (Fig.10).

When suspicious location is found, the user can modify its data immediately. All user needs is just to select the location with the corresponding number in the table. Then, all the textual information for this location is visualized in the right

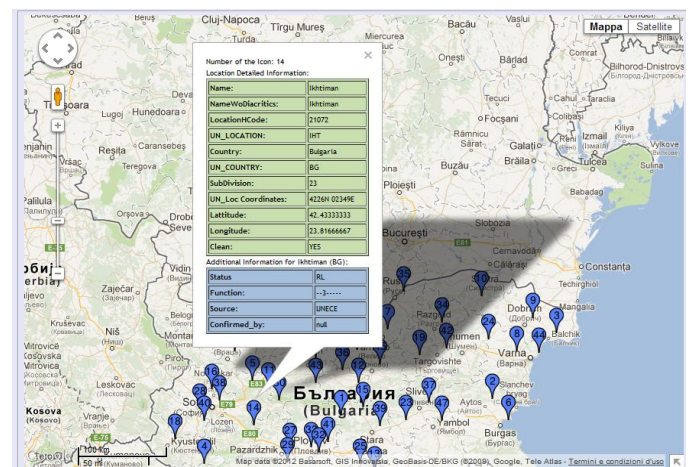


Figure 10. Map interactivity.

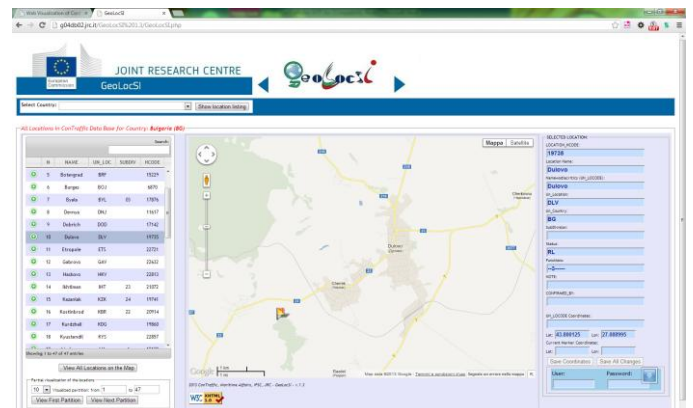


Figure 11. Selection of a single location for modification.

The only textual characteristic of location which cannot be modified is the location_hcode, which is unique identify number of each ConTraffic location. In the concrete example (Fig.11), the actual position is reported far away from the real geographical position. In this case the user can directly type the new geographical coordinates or just drag and drop the icon to the right position (the geographical coordinates of the new position of the icon will be visualized automatically – Fig.12).

When the user modifies some data and he wants to save the modifications in the DB, he needs to use the specific buttons (there are two buttons – one for saving only the coordinates, and another one for saving all the modifications done). The click over any of the saving buttons calls a JavaScript function. This function is responsible for creating the input parameters which will be passed to “db_update.php”.

The input parameter contains the following information: username and password of the user, the location_hcode of the location which must be modified (exactly this parameter is used in the condition section of the update SQL request) and the user modified data. The “db_update.php” file first connects to the ConTraffic DB (assisted by “db_connect.php”) and then control the received as input username and password. If they are correct, (the allowed usernames and corresponding password are stored in our data base in a separate table “GeoLocSI_users”), the program executes the update SQL request in ConTraffic DB and informs the user for successful modification of the record (in case of successful execution of the SQL request) and for unsuccessful updating operation.

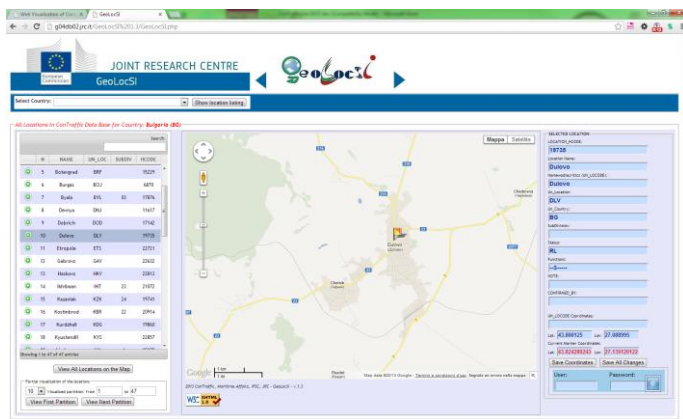


Figure 12. Drag and Drop event used for modification of the geographical coordinates.

V. DISCUSSIONS

In this study, a Web GIS application has been designed for efficient visualization and interactive modification of spatial data in our DB. The prototype allows fast interactive reviewing of location data through Internet with an attractive geographical visualization. The prototype allows the user to create different request to ConTraffic DB according to country name and allows user to review, explore and modify the spatial data for each of the locations in the selected country.

This can be performed in a few different ways. By the first way, the user can review the complete data – the data are presented in complete form just as it is in the DB (ordered in alphabetical order) in tabular and geographical manner (interactive list of locations and geographical map with icons for each location).

By the second way, the user can select and review the data in tabular manner and see the corresponding geographical position of the location. The review of the geographical positions can be performed for all locations from the selected country or just for a single location.

By third way, the user can modify the data in our DB in interactive and simple mode. At any moment the user can select certain location and modify the tabular data just by typing the new data in the corresponding fields. The geographical coordinates can be modified also by interactive drag and drop of the icon. The application was developed by using Google Maps API, JQuery (including also some plug-ins for tabular data presentations in tables) and a number of programming languages (such as PHP, SQL, JavaScript and HTML). The application is successfully used by ConTraffic users. By this application we managed to find a few hundred positional inaccuracies in our dataset and corrected them. The verified dataset of locations and geographical coordinates now is successful used by another web-based GIS application, called “ConTrafficGeo” (Fig.13).

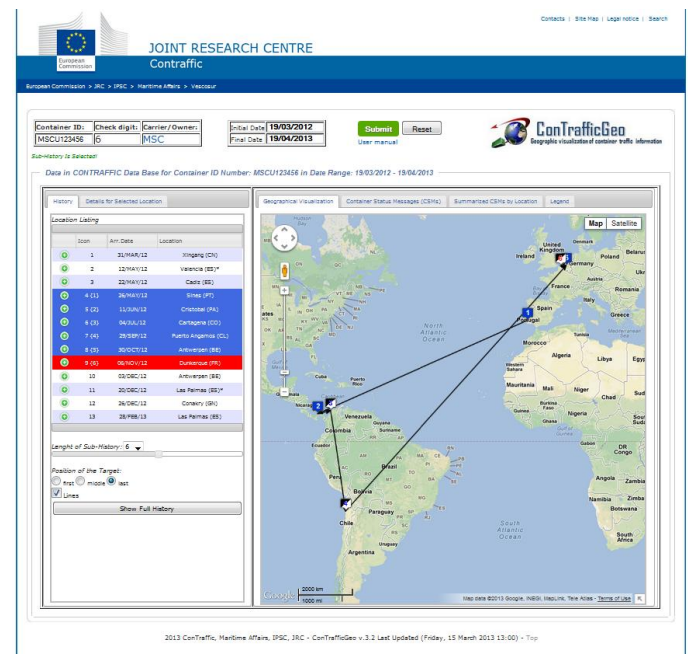


Figure 13. ConTrafficGeo – web-based application for geographical visualization of container movements.

As a limit of the prototype we can mention that it doesn't offer the insert function for new locations. Anyway, the prototype presented in this study can easily be expanded with this new function or other ones because of its structure and

flexibility. The mentioned function was not implemented because it was not necessary at the current moment.

CONCLUSIONS

In this paper we presented a prototype of a Web GIS tool that can help the verification and modification of spatial data. The tool has several selection mechanisms that allow the user to identify quickly what information user wants to view and modify: the initial selection of information based on country name, visualization of the geographical positions of all locations for a selected country (or partition of 10, 20, 50 or 100 locations), selection of a single location, drill-down to the details of any location and search possibility in the tabular presentation by user keyword. The information is presented in both ways: geographical (by icons over a map) and tabular (by textual descriptions for each location in an interactive table). The presentation techniques include: list of all locations for certain country, the geographical map displaying the geographical position of locations (one, subset or all locations). The map doesn't only visualize the data and allows the typical zoom/move map operations but also allows the user to modify the geographical position (coordinates) just by drag and drop of the corresponding icon. Furthermore, the user can drill-down and see details of the location (in info window) by selecting a particular icon.

Integrating our spatial location data into a Web GIS interactive system allows the decision-makers to identify quickly suspicious data and modify it by simple interactive way. The prototype can be used at any computer, it doesn't require any specific knowledge and preparation, it uses very well-known map (Google Maps), it can be open in any browser and uploaded at a server, which will allow users from all the network to use it. It was used for the needs of ConTraffic and it completely satisfied our needs and helped us to solve quite big problem with the inaccuracy positional data for the locations.

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