

Development of a Web-Based Geographical Information System for Interactive Visualization and Analysis of Container Itineraries

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Abstract— The paper describes an advanced prototype of a web-based geographical information system enabling interactive, efficient and user-friendly visualization of the movement of containers travelling around the world. The prototype presents the information stored in the ConTraffic database which contains currently more than one billion records. In order to allow the user to browse and visualize data from such a huge geographical dataset the prototype system implements four different selection mechanisms and three different presentation methods, one of which is the geographical visualization on a map of the locations where the container events were recorded. Key features of the system include the visualization on the map of critical aspects of the data and the semantic summarization of the records while allowing the user to drill-down to all the details available. Risk analysts dealing with the container traffic can use the system through a regular web browser and easily find and understand the information they are looking for. Such a system is expected to allow them to make better and faster decisions. The prototype has been implemented based on the client-server approach using several web programming languages and state-of-the art APIs while remaining flexible and easily adaptable to other similar domains of moving objects.

Keywords-component; *Web GIS, web-based geographical information system, interactive visualization, visualization of multidimensional data, container movements, container trajectory.*

I. INTRODUCTION

Around 90% of the non-bulk cargo is transported in containers travelling by sea. In 2012 the estimated number of containers used for these operations was about 20 millions. Because of the huge number of the containers and the fact that inspection are expensive and create delays, only 2% of them are physically inspected by Customs Authorities. This fact is paving the ground to their potential usage in a number of illicit activities, including commercial frauds, illegal traffic, and even terrorist attacks. That's why new methods for monitoring and analyzing the container movements are studied which could help the Authorities to target suspicious containers and inspect them. Container route based analysis is such a solution which has been considered in a series of studies [1-3] as a key

factor in identifying potentially suspicious consignments. An essential part of container route analysis is the visualization technique which is widely recognized to be very powerful in anomaly detection. In addition, 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. When the dataset is really big, it is very difficult to assess what kind of data analysis techniques could be used for transforming the data. In such cases, the visualization of the data could help significantly by giving an initial general view of container's behavior. In certain cases, this can also indicate abnormal movements, i.e. circles in container itineraries or unnecessary transshipments.

ConTraffic is a unique technology developed at JRC to screen data on global maritime container movements to detect potentially suspicious consignments. It gathers automatically container movements' data from a number of on-line sources and features facilities to target suspicious containers based on analysis of their itineraries. ConTraffic provides several online services for data analysis and presentation of the data in textual shape. Recently the information visualization techniques are used successfully in combination with data analysis techniques to explore and visual analyses of large geospatial data. This is because a proper visualization of container traffic information stored in ConTraffic DB could become a powerful online service for better understanding complex container trajectories. Such a service could allow automatic pre-processing and presentation of the data in such a way that an expert user can identify complex irregularities and discontinuities. In this context, we propose a web-based prototype for geographical visualization of complex container traffic information that circumvents the problem of huge data size and dimensions by exploiting perception capabilities of human visual systems and needs.

The paper is organized as follows: Section 2 gives a short overview of the web-based visualization for data analysis, Section 3 gives a description of the ConTraffic System and DB, and Section 4 presents the initial requirements, proposed

architecture of the prototype, details for the necessary data acquisition and manipulation and description of the realized user interface for data presentation. Finally, in the next two sections, we make a short discussion of the advantages, limitations, usage statistics of the implemented prototype, presenting future improvements and conclusions.

II. WEB-BASED VISUALIZATION FOR DATA ANALYSIS

The success of any performed risk analysis depends a lot on the analysis techniques used. Automatic analysis techniques are usually limited when studying phenomena with unknown or poorly-understood influence factors [9]; such is the case of anomaly detection in container itineraries. Therefore, there is a need of new practical solutions for expert directed analysis of such data. Recently, in several studies [10] some researchers recognized the visualization and interaction techniques as very powerful in maritime domain for anomaly detection. They may close the gap between the domain experts and the data mining engines [11]. 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 big, it is very 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 view of the object's behavior. In certain cases, it can also indicate abnormal movements, i.e. movements in circles, unnecessary transshipments and other.

Recently, the most used and fast way for on-line sharing of any information related to spatial data is the "Web GIS", known also as "Internet GIS", "Web GIS application", etc. The Web GIS have become more and more powerful solutions because of several advantages. These advantages have been discussed by many authors:

- maps and geographical data are easily accessible from everywhere in the world through the Internet [12-14];
- typically used client/server architecture enables the user to access such services without buying and installing any specialized GIS software [15];
- intuitive and user friendly interfaces, so the user does not need any specific training to use the provided functionalities [14];
- possibility for performing online different analysis according to the user defined input parameters and using huge data stored at distant server;
- possibility for the user to download specific set of the data on its own computer for further detailed analysis.
- usage of the proper realization of the DB gives another important advantage of the Web GIS - support huge number of users [16].
- dynamic update of database contents [18] (the data can be updated in the same time when users access the GIS system, so once the DB is updated with the new data the user has access immediately to it);

- predisposition of the data - the most of the information/data today is being collected directly in digital format and sometimes there is not analogue or paper duplicate, so it is much easier to be presented online [13];

- possibility for providing of an information system with "non-stop" services which is very useful feature in case of the distant object monitoring, such as monitoring of maritime transported objects, including containers.

Several approaches present different development of Web GIS applications for on-line visualization of marine data [19-23]. In particular, Kraenzle in his study [22] describes the development of a geographical information system for simulating container movements coming from overseas to the United States in real time. The application demonstrates that millions of containers entering the US may be tracked using a user friendly visual interface that allows the monitoring of containers and the management of the relevant information pertaining to each container. The visualization of the prototype is done by ESRI's ArcGIS. Once the container arrives at the port, it's tracked as it travels via truck or rail to the final destination. The DB contains around 100 000 records. Another study describes the development of a prototype of Japanese web-based marine GIS which manages marine spatial data using ArcGIS [23].

For the development of the Web GIS application, a variety of instruments and methods are available but most of them use the same model called client-side model. The most important advantage of this model is that the complete data is stored on a server (usually very powerful and fast computer), so all procedures for extraction and pre-processing of the data are performed by the server and only the specific part of the data is prepared and sent to the end user's browser for visual interpretation. In this case the speed for access to the user specified data is very fast and the browser have to visualize comparatively a small set of data. These advantages make the model very suitable for web-based visualization of container movement data, which indeed is a huge data set.

Several mapping and visualization services have been made available in the last years: Google Maps, OpenStreetMap, Bing Maps, Yahoo Maps, etc. Most of them can be integrated from the programmers easy and allow the application to have access to big quantity of detailed maps. Several studies discuss the potential of the Maps API for GIS application development [24-28]. In a particular study [25] the authors make research of the Google Maps usage based on criteria for design and evaluation of an exploratory geographical visualization by Koua [26-28] states that GIS applications using API such as these of Google or Microsoft provide to the end user exactly that they really need: simplicity, immediacy, accessibility, responsiveness, and low cost of the development.

Different technologies can be used for realization of the server-side part of a Web GIS application. Highly popular choice for this is the PHP programming language [29, 30] because it can be embedded easily in XML or (X) HTML pages, it is a very suitable solution for creating dynamic data

driven web-pages as those generated by web GIS systems. The Apache http server is very frequently chosen with similar reasons and for the client side [29] while JavaScript is a commonly used client side scripting language [30].

The combined usage of client-side and server-side programming languages reduces some limitations of the client-server model (permanent communication of the client with the server and the dependence from the data on the server).

A survey of available web services for maritime tracking [31] shows that not many of the websites offering maritime tracking provides geographical visualizations of the vessel/container itineraries.

III. CONTRAFFIC SYSTEM AND DB

The ConTraffic system gathers data on container movement from a number of on-line open source repositories. The data is gathered in terms of little pieces of information, called “Container Status Messages” (CSM). Each CSM presents a single event or status of a container. It has semi-structured information describing the performed actions or the status of the containers. Currently the ConTraffic database contains more than 1 billion CSM records making the task of analysis or visualization quite challenging. Every CSM includes:

1) The ISO 6346:1995 [4] container identifier as assigned by the Bureau International des Containers et du Transport Intermodal [5]. It is composed by: a code for the owner of the container; a code for the category of container (they both together compose the BIC code); a serial number, namely container number; and a check digit. If we consider the following string “**ABCD1234567**” as a container identifier, the symbols “**ABC**” identifies the owner company, “**D**” presents the container category; “**123456**” correspond to the serial number of the container and the last symbol shows the check digit which can be computed based on the values of the previous 10 characters. The container identifier with or without the *check-digit* symbol will be referenced as *container ID*.

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 [7]. Each record contains the UN_LOCODE, a UN assigned unique (per country) code, the ISO code of the country, the name of the location, 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 (or status).
- 4) Date and time when the event occurred.
- 5) Text description of the load status of the container (full/empty).
- 6) 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 there are several challenges in interpreting and integrating the data. Furthermore, the data is sometimes not complete and it may even contain errors. 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 applications, including the application described in [8] and GeoLocSI. GeoLocSI (Fig. 2) is a web-based GIS application used for verification and modification of location data in the ConTraffic DB.

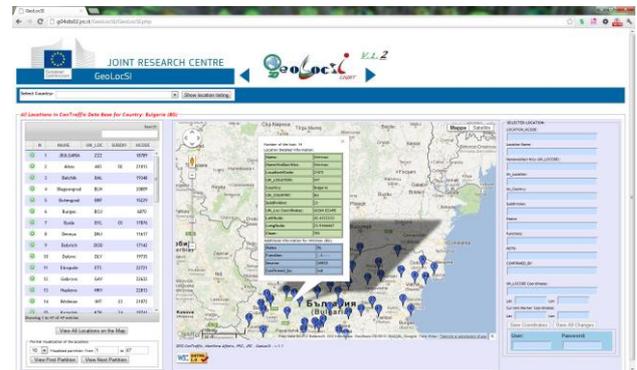


Figure 2. Screenshot of GeoLocSI showing locations for selected country.

One of the applications of ConTraffic that heavily depend on the location cleaning process is the ConTrafficGeo; a service which enables the geographical visualization of container movements. In order to visualize the container movements the application needs to know the geographical coordinates of each referenced location, i.e. it needs that each text description of a location is mapped to a standard location of the ConTraffic database. The design and the implementation of ConTrafficGeo are described in the next section.

IV. REALIZATION OF WEB-BASED GEOGRAPHICAL VISUALIZATION OF CONTAINER MOVEMENTS

A. Initial requirements and possible solutions

Several initial user requirements have been defined for the geographical visualization of container movements:

- it must be implemented as a web-based application with a simple and intuitive interface and accessible through the Internet using a typical web browser.

- it should be able to extract from ConTraffic DB the *container history* of a single container according to user defined parameters - *container ID number* and *date range* (date period of interest defined by *initial and final date*).

- the extracted *container history* data should be pre-processed in the vague way and presented in two ways - graphical and textual with interactive relations between them.
- the graphical presentation of the data should be realized by well-known maps providing specific interactivity.
- the textual presentation of the data should present the data (clean and raw data) with specific interactivity.
- possibility to select and focus on sub-parts of the extracted *container history*.

Considering the requirements, the following programming instruments were selected as most proper:

- SQL for DB related operations (request data).
- PHP as server-side programming language for connecting to the DB, preparation of the user request as SQL request, pre-processing of the extracted data and generation of interactive webpage with dynamic contents;
- JavaScript as client-side programming language for user interactivity and implementation of the functions for user manipulation and visualization of the extracted dataset.
- JQuery library and DataTable plug-in for providing the interactivity of the textual presentation of the data and providing user manipulation of the extracted data.

B. Architecture

The architecture of the proposed prototype is presented in Fig.3. The GIS application is driven by “ConTrafficGeo.php” main script stored on the ConTraffic server. This script is responsible for the creation of the structure of the dynamic page, pre-processing and visualization of the extracted container data. The maps are charged from the Google Maps Server with activated well known map controls (zoom, selector of map type, etc.). The application is accessible from any computer using a web browser. Once the browser loads the URL address of the application, the PHP part creates the initial page and sends it to the user browser as simple web page (Fig.4). Then, the user can insert the input parameters, which will reload the page, and the PHP part will process the input parameters, create appropriate request to the DB, extract, pre-process and present the corresponding data in the new generated web page.

For the current version of the application, the input parameters are the container ID number (which can be inserted with or without the *check-digit*) and the date range of interest. The container ID number is a string of digits with length of 10 symbols (11 - with the check digit). Once the user types the container ID number, assistant functions connect to the ConTraffic DB and extract the carrier name and re-calculate the check digit. Beyond for the container ID number, the user must insert the date range as initial and final date. As a default period of interest the last two years is considered. The selection of the *date range* can be performed by interactive

JQuery calendar (Fig.5) where the control of the compatibility of the *initial and final dates* can be provided by simple activation and deactivation of the possible dates for selection. All user input parameters are controlled for correctness and only if they all are correct the button “Submit” is activated and the user request for container data can be executed.

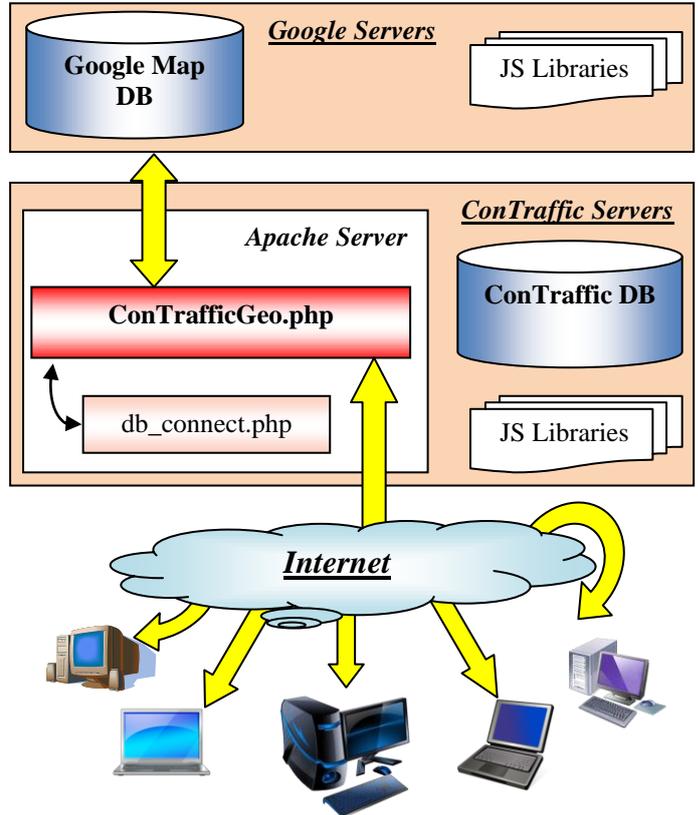


Figure 3. ConTrafficGeo architecture.

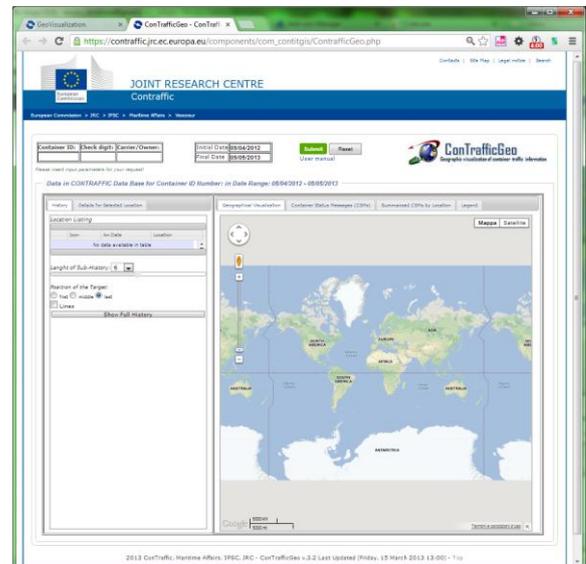


Figure 4. Initial page of ConTrafficGeo.



Figure 5. Selectable date picker.

C. Data Acquisition and Manipulation

Each ConTrafficGeo session initiates with a control of the input parameters. If they are not null a new connection to the ConTraffic DB is established and automatically generated SQL request is executed in order to extract the data for container behavior during user selected data range. As it can be supposed from the content of Section 3, where the ConTraffic DB was presented, this data is multidimensional and sometimes it can be quite huge. As Helmut [32] tells, any visualization of such multidimensional data needs to be transformed to multidimensional metadata without losing the semantic relationship between the multidimensional data vectors and the original data. This speeds up the human finding, interpreting and understanding of the information because the data is presented in compact way.

The data in our DB is distributed in many tables, but the dataset DS (1) for all movements of a certain container in a certain data range can be extracted by quite simple SQL request considering only two dimensions – container ID number and date range. The dataset is ordered by chronicle order according to the date of the event. The received dataset from the DB can be presented as series of N -records (where N is the number of the events occurred on the container in the selected date range). Each of the records can be presented as a vector CSM_i where $i \in [1, N]$.

$$DS \Rightarrow \begin{pmatrix} CSM_1 = [E_1; L_1; D_1; S_1; C_1; V_1; T_1] \\ \dots \\ CSM_i = [E_i; L_i; D_i; S_i; C_i; V_i; T_i] \\ \dots \\ CSM_N = [E_N; L_N; D_N; S_N; C_N; V_N; T_N] \end{pmatrix} \quad (1)$$

Where E, L, D, S, C, V, T are vectors which contain data according to the basic dimensions, as follow:

- $E = [e_{1,1}; \dots; e_{1,k}]$ – it is event related data and it includes: raw event string (it is the *unclean event*), indicator for the status of the event (if it is categorized by ConTraffic as a *standard event* or not), the corresponding *standard event* (in case of a *clean event*).

- $L = [l_{1,1}; \dots; l_{1,m}]$ – location related data and it includes: raw location data (it is the *unclean location*), indicator for the status of the location (if it is *clean* or *unclean location*), the identification and detailed data for the corresponding *standard location* (in case of *clean location*) – location name, un_lococde code, un_lococde code of the country, country name, function, geographical coordinates, etc.

- D - date and time of the event.
- S – load status of the container.

- C – carrier name.
- V – vessel name.
- $T = [ts_{1,1}; \dots; ts_{1,p}]$ - it is shipment related data and it includes: voyage ID, bill of lading, etc.

The extracted dataset DS is transformed by PHP in abstract meta dataset DS' (2) which presents the same data but summarized and ordered in chronicle order according to the locations of the events.

$$DS' \Rightarrow \begin{pmatrix} R_1 = [E'_1; L'_1; D'_1; S'_1; C'_1; V'_1; T'_1] \\ \dots \\ R_j = [E'_j; L'_j; D'_j; S'_j; C'_j; V'_j; T'_j] \\ \dots \\ R_V = [E'_V; L'_V; D'_V; S'_V; C'_V; V'_V; T'_V] \end{pmatrix} \quad (2)$$

Where $V \leq N$ and presents the number of the locations where the container have been during the selected date range, $E'_i; L'_i; D'_i; S'_i; C'_i; V'_i; T'_i$ are transformation of the vectors E, L, D, S, C, V, T which contain summarized information for each location from DS , according to follow the equation:

$$X'_j = \bigcup_{b=1}^Q X_b \quad (3)$$

Where $j \in [1, V]$, Q is the number of events occurred at location j . Note that the union operator removes any duplicates from X'_j .

During the extraction of the data from ConTraffic DB, the PHP part stores the datasets DS and DS' in PHP arrays and includes some additional indicators giving at any moment the correlation between the data in both datasets (in DS and DS' we have chronicle number for each row; for each CSM in DS we store the chronicle number of the corresponding R in DS' and the opposite - in DS' for each R we store chronicle numbers of the first and the last corresponding CSM from DS). Some additional procedures scan the data and add some additional indicators used during the data presentation (for example, classification of some CSM as *future CSM (future events, future locations)* when the date of the event is before the date of the data publishing, classification of some locations as *country-locations*, when it is known only the country of the location, creation of indicator for the summarized status of the container for each location, etc.).

D. Data Presentation

Once the pre-processing of the data is finished, both PHP arrays are converted to JavaScript arrays by `JSON_ENCODE`, which are used for the data presentation and user interactivity. This transformation is performed in the initializing JavaScript procedure which checks if the browser is compatible, performs some initial definitions and settings of the map and if container data is available calls functions for the geographical and tabular visualization of the data.

In the left side of the map (Fig.4) there is a panel called *location listing*. It serves for fast view of the main information. It contains the listing of the locations in chronicle order and for each one the user can access extra information

by clicking on the green round button with plus inside (Fig.6). The extra information includes the dates of arrival/departure, events, status of the container and the vessel involved in the event. The number of each location (column Icon) in the location listing corresponds to the number of the corresponding icon in the geographical visualization. *Unclean locations* don't have numbers and they are listed in grey, the *future locations* have indicator “*” in the end of their names.

Icon	Arr.Date	Location
+	5 11/JUN/12	Cristobal (PA)
-	6 04/JUL/12	Cartagena (CO)
Arrival-Departure: 04/JUL/12-11/JUL/12		
Event: DISCHARGED;DERAMPED;INLAND TRANSPORT;GATE OUT;EMPTY RETURNED		
Status: FULL EMPTY		
Vessel: HELVETIA;-		
+	7 29/SEP/12	Puerto Angamos (CL)
+	8 30/OCT/12	Antwerpen (BE)
+	9 06/NOV/12	Dunkerque (FR)
+	10 03/DEC/12	Antwerpen (BE)

Figure 6. Location Listing.

1) Geographical visualization

The geographical visualization is performed using the dataset DS' by layers with icons and arrows over Google Map (using Google Maps API v.3) (Fig.7). The arrows are used for indication of the chronicle order and the direction of the container movements. Helmet [32] summarizes in his study that the arrows are the perfect way for presenting lineal structure of data and for presenting different characteristics in multidimensional data, good practice is the usage of different colors, icons. That's why we use different icons indicating different characteristic of the container during its travel. The center of the map and the zoom are calculated in order to include all the locations of the container movement data. The visualization of the arrow layer is optional and the user controls it by the check-box. The icons present each location from the extracted container dataset and the numbers and filling indicate for the sequence number of the location in the extracted *container history* and the container status at this location. Only one hundred numbered icons are used, so if the requested *container history* contains more than 100 locations, the location after the 100th are drawn by black icon without number. This limitation is accepted because a trajectory with more than 100 locations is non-understandable. When the user moves over some icon, a little info-window is visualized showing the name of the location (Fig.7), when the mouse is over arrow – another info-window showing info for the departure and destination location is shown.

For each icon an info-window is available after click on the icon (Fig.8). This info-window includes detailed

information about the events and status of the container at this location, and the date range of the stay.

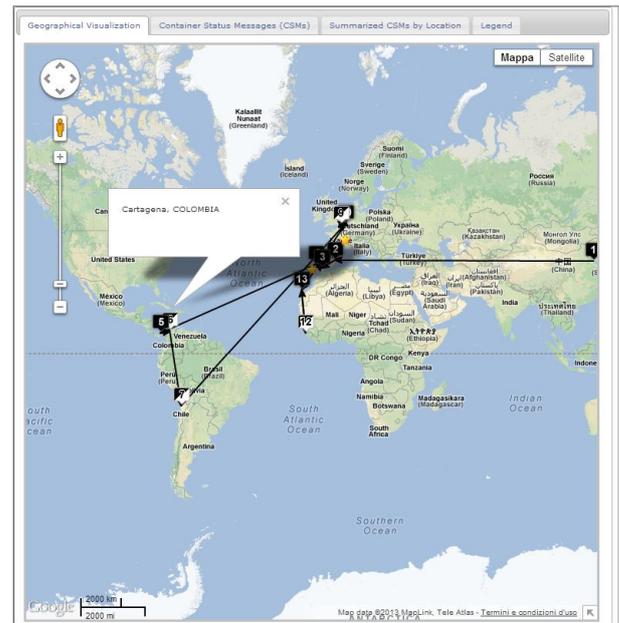


Figure 7. Container history visualization.

More detailed information is available in the tab “Details for Selected Location” (Fig.8) where the user can see: listing of all vessels, voyages, carriers, involved in event(s) at the selected locations, previous and next few locations (the current location is highlighted with a green background) and geographical details for the location.

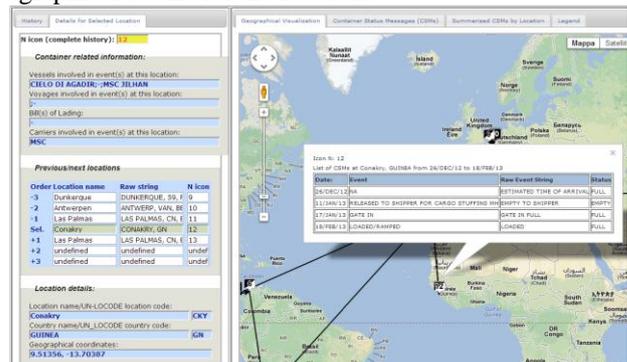


Figure 8. Detailed information for selected location.

The *location listing* can be used by the user for visualization of sub-set of the extracted *container history*, called *sub-history*. Once the *container history* has been extracted for the specific period of time, the user can define a *sub-history* for geographical reviewing by selecting a location target in the location listing (Fig.9). The target is presented by blue background in the location listing and in the geographical visualization by a red icon with the sequence number of the corresponding location in the selected *sub-history*. A target can be only a *clean location*. The sub-history is determined by three parameters – *target*, *position* of the target in the *sub-history* and *length of the sub-history*. All of them are user defined. The *length of the sub-history* in the current version of

the application can be maximum 10. The *position* of the target can be first, last or middle. The following rules are defined by default:

- a *sub-history* is limited by the initial *container history*; with other words locations outside of the extracted already *container history* will be considered no matter the input parameters.
- if the user selects an even number for *length* of the *sub-history* and the *position* of the target is middle, the *length* of the *sub-history* is automatically increased with 1.

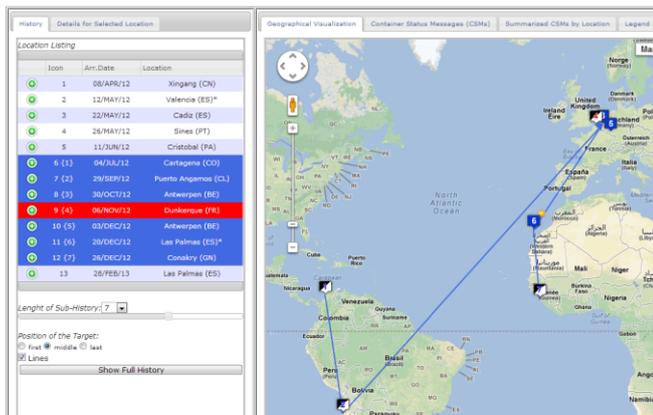


Figure 9. Sub-history with middle position for the target.

When a *sub-history* is selected, in the location listing panel also the number of the used icons are included. In any moment the user can review again the *container history* (button “Show Full History”). At any time, the *sub-history* parameters can be modified, and a new *sub-history* is re-drawn.

2) Tabular visualization

The tabular visualization is performed using both datasets DS and DS’. It is realized by Data Table plug-in for JQuery. All the data is sorted by default according to the date of the event (Fig.10). Moreover, the user can change the order of the data. Data filtering is allowed as well by typing a keyword in the Search field to filter the visualized data.

The tabular presentation of the event-based dataset (DS) is presented by a table with rows for any events ordered initially in chronicle order (Fig.10). The tabular presentation of the event-based dataset is presented as a table with a row for any location from the extracted *container history* ordered in chronicle order. Each row in the second tabular presentation corresponds to one location from the *container history* and it includes summarized data for all the events occurring in this location, all the vessels included in this events, the status of the container during its stay in each location, the dates from the first event to the last event happened on this location, etc. Yellow background and symbols “*” in the name of the location name indicates for *future events* and *unclean locations*.

At any moment, the user can download the tabular data on the local computer in a few formats – pdf, csv, xls or just to copy the data in the clipboard memory.

#Loc	Location	Country	Icon	AllEvents	F/Date	Carrier	Vessel
1	Xingang (XGG)	CHINA (CN)	1	GATE IN; LOADED/RAMPED	08/APR/12-08/APR/12		MSC CAMILLE
2	Valencia (VLC)*	SPAIN (ES)	2	NA	12/MAY/12-12/MAY/12		MSC CAMILLE
3	Cadiz (CAD)	SPAIN (ES)	3	GATE IN; LOADED/RAMPED	22/MAY/12-25/MAY/12		MSC ASLI
4	Sines (SIE)	PORTUGAL (PT)	4	DISCHARGED/DERAMPED; LOADED/RAMPED	26/MAY/12-31/MAY/12		MSC ASLI; CHARLOTTE C. RICKMERS
5	Cristobal (CTB)	PANAMA (PA)	5	NA; TRANSHIPMENT; DISCHARGE; LOADED/RAMPED	11/JUN/12-03/JUL/12		CHARLOTTE C. RICKMERS; HELVETIA

Figure 10. Tabular presentation of the location-based dataset (DS’).

V. DISCUSSIONS

In this study, a Web GIS application has been designed for efficient visualization of container movements. The prototype allows fast interactive reviewing of container historical data through Internet with an attractive geographical visualization. The application was developed by using Google Maps API, JQuery (including also some plug-ins for calendar and tabular data presentation in tables) and a number of programming languages (such as PHP, SQL, JavaScript and HTML). The application is successfully integrated in the ConTraffic website and is currently accessible only by ConTraffic users.

During the testing, the prototype was used for requests with different periods of interest, up to 10 years of duration and the prototype did not show problems with visualization of the quite huge data.

The prototype allows the user to create different request to ConTraffic DB according to the user specific input parameters and allows him to review and explore the data in a few different levels. First level is the complete data – the data is presented in complete form just as it is in the DB ordered in a in tabular view. At second level the data is pre-processed and summarized, so the user see the information summarized according to the location where the container have been – the summarized data in this way is presented in tabular and geographical manner (interactive listing of locations and geographical map with icons for each location from the container history). The third level of data reviewing is provided by interactivity - at any moment the user can see more details for some summarized already element from the data, can review only sub-history from the complete container history, etc.

VI. CONCLUSIONS

In this paper we presented a prototype Web GIS tool that can help the risk analyst to interactively browse, visualize and then understand massive amounts of container movement data. The tool has four selection mechanisms that allow the user to quickly identify what information he/she wants to view: the initial selection based on <container ID, time period>, the sub-history function, the drill-down to the details of selected locations and the free text search. The selected information is presented in various ways: geographically, in tables, summarized or detailed. The presentation techniques used

include the list defining the sequence of locations visited, the geographical map displaying the sequence of locations visited (linked with or without arrows), the table with the container movement details summarized by location and the full detailed table of container movement data. The geographical map not only allows for the typical zoom/move map operations but also uses dedicated symbols to visualize critical aspects of the summarized information, i.e. if the container is full or empty. Furthermore, the user can drill-down and see details of the events recorded by selecting a particular location.

Integrating container movement information into a Web GIS interactive system allows the risk analysis decision-makers to quickly identify useful intelligence. Therefore, there is the opportunity for better informed and faster decision-making. The prototype presented in this study can easily be expanded and integrated into other systems because of its structure and flexibility. It can easily be transformed and used in applications with different purpose; for example a GIS visualization system for moving objects.

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