TRACKING AND TRACING SOLUTION FOR DANGEROUS GOODS CARRIED BY INTERMODAL TRANSPORT

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Keywords: tracking, goods transportation, software, information technologies
Abstract: This paper deals with the problem of designing a complex tracking and tracing solution for dangerous goods transportation with the support of modern information technologies. This research activity presents a part of the "ChemLogTT" [2] project solved at the University of Žilina. The main goal of our contribution is to present basic conception of a complex developed software tool for monitoring and analyzing mentioned dangerous goods transportation.

1 Introduction

Several thousands of various means of transport carrying dangerous goods circulate within European transportation networks every day with the aim to satisfy given requirements. They utilize urban and rural roads, highways, railways and rivers as well. When planning the routes of particular vehicles for such transportation it is necessary to take into account that they are not allowed to access certain areas. One of the main reasons is the character of transported cargo which can be flammable, explosive, corrosive, or even radioactive and may cause fatal consequences in case of a serious accident. Another, but not less important is the fact that vehicles carrying dangerous goods are not allowed to enter tunnels, long bridges or specific geographical areas with natural resources like sources of water. Improper handling of dangerous goods can easily result in environmental contamination, huge material losses or even death of many people. That's why this kind of transportation must be monitored and managed properly due to potential risk for society and nature. [2, 3] In recent years, great progress has been achieved concerning the improvement of transportation safety and increasing the quality of European transportation networks. In spite of that, accidents still place a heavy toll, both in terms of human life and economic damage. Therefore a big effort has been made to implement many sophisticated solutions to improve safety of dangerous goods transportation. [1] Recent advances in computing and Information science offer the opportunity to decrease the impact of the accidents that may happen at a statistically predictable rate. By utilizing a systemic approach, real time infrastructure information, detailed and accurate knowledge of the materials being transported and the vehicles transporting them, on-board sensors, many useful advanced algorithms are being developed. Realization of such information systems may significantly contribute to improving safety of people and environment and developing methods to minimize damages and costs, improving the exchange of information between centers of production, carriers, receivers and emergency centers and determine methods of cooperation at the place of a breakdown.

In this paper we present a universal software tool for analyzing and monitoring dangerous goods transportation based on geographical data processing and visualization.

2 System design

2.1 GPS Trackers

GPS trackers are commonly used in cars for various purposes. Companies used them for checking the usage of cars, determination if the cars are not used for employers personal purposes or company can make available online the information of product positions for customer. Another frequent use of GPS trackers is to quickly locate the vehicle after the theft. There are many different types of GPS trackers which are offered by various vendors. Most of them consist of GPS module for location, GSM module for online transmission of information, high capacity battery (there exists also versions with external power supply) and various sensor devices according to where are deployed (thermometer, accelerometer, gyroscope, etc.). These all devices are inserted into the

Acta Logistica - International Scientific Journal
Volume: 1 2014 Issue: 1 Pages: 27-30 ISSN 1339-5629

resistant box and may have external antenna for GPS or GSM signal or for another sensors. Figure 1 shows GPS tracker on a rail wagon. Some manufacturers of GPS trackers specified battery life up to three years on a single charge. It depends on the number of sensors, frequency of transmission, signal of GPS and GSM networks and the other factors. One of the objectives of our research is to monitor batteries life and their usage in various types of trackers.

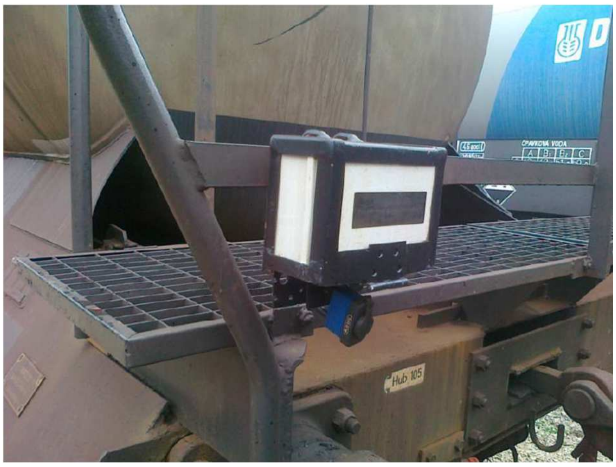

Figure 1 GPS tracker in box on a rail wagon

GPS trackers mostly communicate in a one way from tracker to server via GSM module. There exists also trackers which communicate in both ways, but there are more energy intensive and expensive. We are working with trackers that send information with an interval from 10 second to a few minutes from different vendors.

2.2 GPS Trackers problems

The big problems for such a monitoring system are territories without the coverage of GSM signal. For some trackers it is possible to record information on an intern medium and then send all the buffered data at once when GSM signal is reached. However, the problem that we have not actual data still remain. There is no possibility to respond to a situation that occurs. The second problem is the territories without or with low coverage of GPS signal. The shorter outage of GPS signal can be corrected by analysis of previous and subsequent positions data. Another reason of GPS outage can be for example when the cargo container is loaded into enclosed space into a ship. This outage will last during the entire cruise of ship. In such cases it is appropriate to integrate the ship or another transporting positioning system (for example marine traffic [5] in water transport) which can send missing data to our system. The integration of these systems is not easy especially if we require information in real time.

2.3 Tracked events

Position – actual position, designed system allow visualizing actual position, speed, direction and the other data from sensors. See figure 2.

Figure 2 Online actual position with last 10 positions

It is possible to show overall routes of selected containers or for example see all routes of all containers in selected area. See figure 3 and figure 4.

Speed, temperature and other sensors – with respect to the type of dangerous goods it is possible to set alert sending after exceeding a defined value of sensor. For example when the temperature of cargo is increased or the driver exceeds the maximal speed operator is informed real-time via email or SMS to deal with the situation.

Crash detection – using the accelerometer it is possible to detect cargo crash. Accelerometer in GPS tracker is checking the force vectors and after the exceeding allowed value in resulting force vector GPS tracker sends the information about crash and buffered data for a more detailed analysis to a server. We have not still crash detection fully solved because for example when the cargo is loaded or is manipulated with it sometimes the resulting force vector is greater or equal then crash force vector. Because of these situations it is appropriate to check another data of cargo sensors (position, speed, etc.) to determine if it was really an accident or not.

Figure 3 The routes of two containers

Acta Logistica - International Scientific Journal
Volume: 1 2014 Issue: 1 Pages: 27-30 ISSN 1339-5629

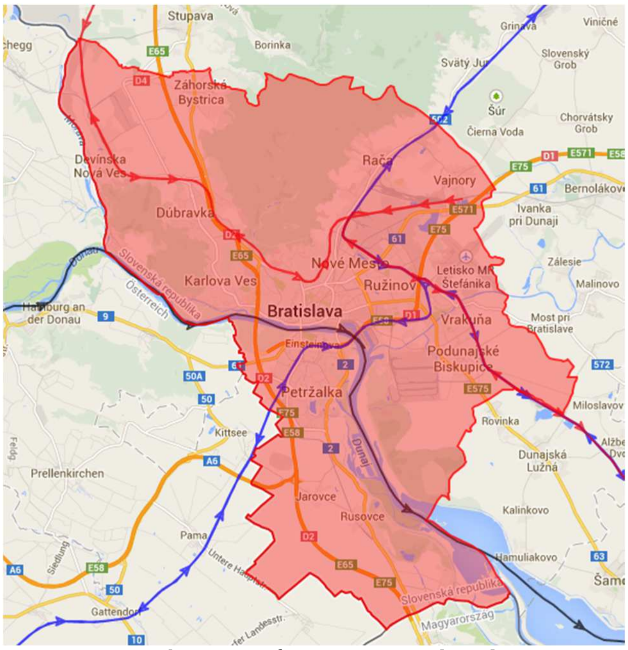

Figure 4 The routes of containers in selected region

2.4 *GPS Trackers problems*

Designed system allows monitoring entry to restricted areas. There are containers with hazardous materials that cannot entry for example to an area where the drinking water source is, national park or cannot enter the tunnel for security reasons, etc. The restricted areas are permanently checked with each new position of GPS trackers and after crossing the entry area of restricted area designed system generates email or SMS to competent person to deal with the situation and alert the danger. See an example on figure 5 to monitor the tunnel. Designed system has to send an alert in sufficient time to prevent the entry.

Another planned functionality is to send customized information to maintainers of regions, countries or other areas. For example the maintainer of Bratislava region gets on-line information about each entry of containers and will be allowed to track the movement of the containers on his territory. Also the alerts will be sent to him during the transit through his area. After exiting his area the report with relevant information and path will be sent to him and archived for further reports.

3 System implementation

We actually test multiple devices. Each GPS tracker vendor provides another user API with different functionalities. There is no user API which provides all the functionality we need. So we built an own server system where all the information from GPS trackers are real-time sent through providers services. Most of providers offer WSDL services to get raw data from the trackers. We catch these data in a loop and store it to the database. We build also a service which checks alerts (restricted region entry, exceedances of sensors) and send them to competent person. Some data are imported to our system for testing purposes not on-line (some containers have two different types of GPS trackers and one of them is off-line for testing). We implemented web user interface using Google maps API (JavaScript, AJAX, web services) [4] which offer cheap and simple tools for drawing and working with maps. Our system offer real-time web user interface and exports of raw data in CSV, XML and KML exports for geographical data of paths, events and regions. We have some minor problems to obtain the coordinates of EU countries and region borders. We used free geo databases [6], but the data are not precise enough so we are still working on their improvement.

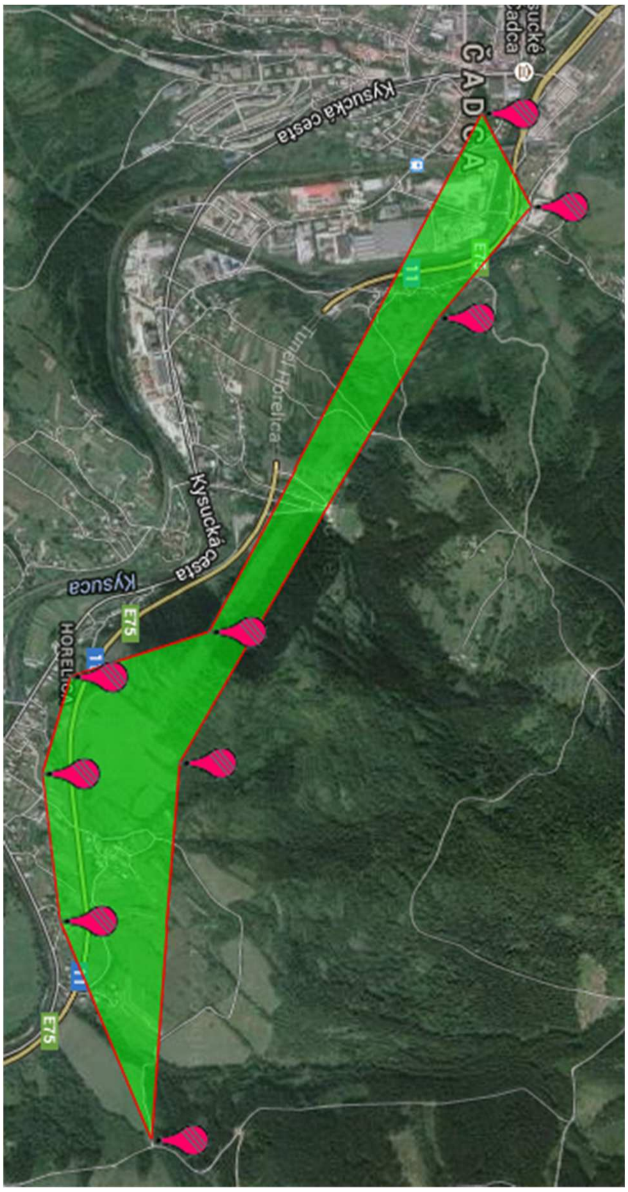

Figure 5 Monitoring the entrance to the tunnel by restricted area (tunnel Horelica)

Conclusion

This contribution was aimed at the designing of a complex tracking and tracing solution for dangerous goods transportation within the European transportation networks. Monitoring of actual state, features and movement of any dangerous material plays a very important role in human and environmental safety, that's why big attention has been paid to this research area, mainly to minimize potential fatal consequences in case of serious accidents. The consequences may take many forms like environmental contamination, huge material losses or even death of people. The substantial contribution of this paper consists in suggested universal software solution based on new information technologies. As we have mentioned, the necessity of permanent monitoring of dangerous goods transportation has led to the implementation of complex systems that enable monitoring and visualization of big amount of data obtained from the devices connected to particular means of transport. We have presented a system design based on Google API, real-time geographical data processing and visualization of results in a proper form for the users. Despite the fact that our application involves a lot of useful features and different settings presented in this paper, there are still many possibilities for extension. As a part of future possible research, we would like to implement a global interface which would support the integration and cooperation of existing systems and overcome the disadvantages of them which consist in different standards. Each company usually provides its own application that is not capable of communication with other systems. Furthermore, our solution can be easily extended by implementation of new features and services. Similar monitoring systems are usually connected with large databases providing real time infrastructure information, detailed and accurate knowledge of the materials being transported and the actual weather situation which can also influence the goods transport. By these new features we would like to achieve improving the exchange of information between centers of production, carriers, receivers and emergency centers and determine methods of cooperation at the place of a possible breakdown. Therefore the future research in this area will be oriented at developing new functions according to the users requirements and common standards in mentioned field.

Acknowledgement
This paper is supported by the following project: University Science Park of the University of Zilina (ITMS: 26220220184) supported by the Research&Development Operational Program funded by the European Regional Development Fund.

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