Proposed Architecture for dealing with Transport Big Data via Cooperation Between Different Transport Systems

Ayman M. Ghazy*
Ministry of Transportation, Cairo, Egypt – ayghazy@mot.gov.eg

Abstract

In the last decades the sources of transportation data have been multiplied and the volume of data became of huge amount, especially with the using of ITS (Intelligent Transportation Systems), the data are collected from various sources and sensors. Transportation data is very important either for daily management of traffic flow and fleets, or even for planning for the future. These data can be owned by different transportation authorities, company...etc. The processing on transportation data is performed on scattered systems to meet the requirements of each system. This paper presents architecture for maximize the benefits of using data that exist on each system to serve other systems, via cooperation between systems. The cooperation between systems can be implemented by perform some extra process on each system to extract special information or indicators, that can serve other systems, and passing these information or indicators to other systems. The architecture represents how some of the most important transportation systems can cooperate between each other, from this architecture we can conclude that many indicators and statistics will be available with a minimum processing cost, instead of recollect and entering data or make a costly survey, also the proposed architecture provide a sustainable way to retrieve the important information to serve different systems, by this way the performance of transportation systems can be increased and more suitable decisions can be taken based on accurate real time information, also the using of survey can be decreased by extract all possible data , indicator and statistics from the available systems.

Keywords: Big Data; Transportation; Systems; Architecture.

1. Introduction

Big data refer to very large data sets, tools and procedures those used to manipulate and analyze such data. The main characteristics of Big data set are, its big volume, exists on a variety of sources, and changes with high velocity, today this type of data is widely available (McAfee and Brynjolfsson 2012). Also, big data refers to the ability to make valuable derivations by analyzing the huge amount of data, which cannot be revealed by using smaller data and traditional methods Mayer-Schonberger& Cukier (2013). One of the Big Data main aspects is to work on extract all valuable information from the large flow of raw data, and work on minimize the processing costs Khan et al. (2014).

Recently with the wide using of Intelligent Transportation Systems (ITS), the sources of the transportation data varied and its volume is extended, especially with a dynamic flow of data from different daily working systems and from different types of sensors These huge amount of raw data can be used by different systems to reflect the current situation of the transportation networks.

Good control of the traffic flow within the city became one of the main issues of smart cities and it depend on using all available opportunities to building smart applications capable of utilizing all available data to enhance their operations and outcomes Al Nuaimi et al. (2015).

There are many transportation applications that used to enhance the performance of the transportation system. ITS applications can be classified under one of the following eight main groups, Mathew, (2014):

1. Travel and traffic Management
2. Public Transportation Operations
3. Commercial vehicle operations
4. Advanced Vehicle Control and Safety Systems
5. Emergency management

6. Information management
7. Maintenance and construction management
8. Electronic Payment

Each of Transportation application has its own function, and it can cooperate with other application. But in fact maximize the cooperation between the transportation applications, either ITS applications or other applications those used for planning or for manage the daily working, will enhance the overall transportation system.

In this paper, architecture to increase the cooperation between different transportation applications is proposed to describe, how these applications can be cooperated between each other, to increase the use of all existing data for different purposes.

2. Transportation Big Data Sources and Applications

Different traffic detecting sensors like, RFD (Radio Frequency Detector), Cameras, Inductive Loops…etc., are used to collect different type of data about the traffic situation, for instance traffic count by vehicle type, travel time, speed. These data can be used on different systems. Each of these systems has its own functions, but in fact the cooperation between different systems can increase the performance of each other, and enhance the performance of the transportation at all. In addition to that, the cooperation of ITS systems with other information systems can be seen as a sustainable way to retrieve the required data for planning, and also it safe a lot of costs that spent in make some type of surveys for instance.

- Traffic volume can be used for compute the level of service of the road by computing (V/C), where V is the current volume, and C the designed capacity of the road. These data can be further aggregated and processed to get the average level of service per season for the roads. These data are very important for future planning.
- Traffic volume also can be used by determining a screen lines on the road network, to study the flow of traffic between different regions of the country, these information is very important for transportation studies and can save a lot of costs that directed to survey to get such information.
- Travel time needed to pass each link on the road network is an essential data for the Dynamic Routing System, Travel time values are used by time table subsystem and routing algorithms to detect a good route between each source and destination on the road network.

3. The Proposed Architecture to cooperate between different Transport systems

The proposed architecture present a way to increase the cooperation between different transportation application, such that by adding a few amount of processing to some applications , we can retrieve a very important information and statistics that can serve other applications, decision makers or studies.

In the proposed architecture we make a focus on the Dynamic traffic routing system and how can this system cooperate with other systems, see Fig 1. There are two direction of cooperation, either the system is receive a data from other system to enhance its performance, or the system make an extra processing to produce some information that serve other systems or statistics.

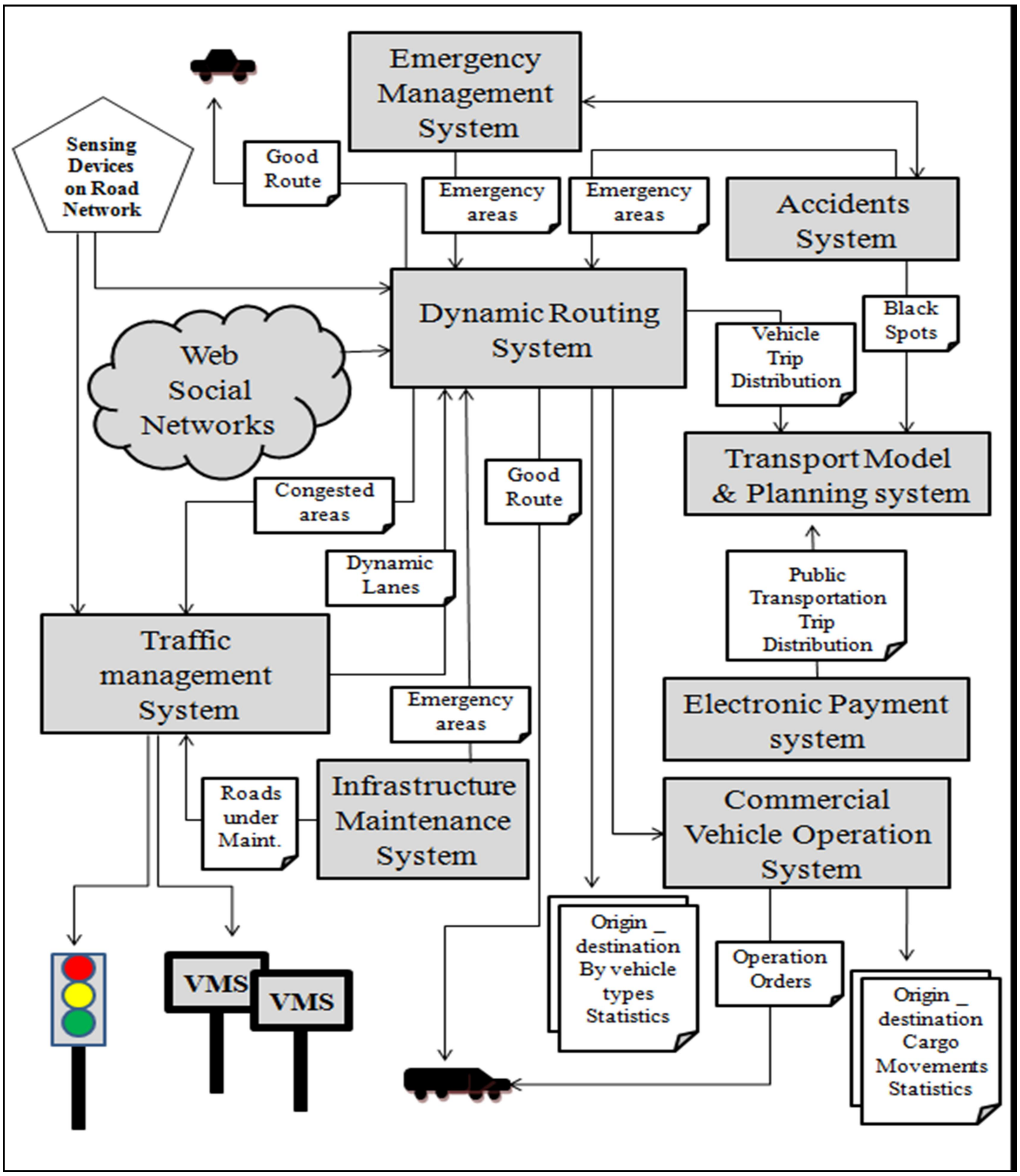

Fig. 1: The Proposed Architecture for dealing with Transport Big Data via Cooperation Between Different Transport Systems

In the following we well describe in more detail how by using the proposed architecture can different systems serve each other.

<u>Dynamic Traffic Routing System, see Fig. 3:</u>

Dynamic Traffic Routing System is used to direct the traffic flow to the good routes and decrease the demand on the congested areas [Claes &Holvoet (2011), Claes & Holvoet (2012)] the recent trends on dynamic routing algorithms that used in routing systems works on periodically find the good route between each source and destination on the network [Ghazy & Hefny (2015a) , Ghazy & Hefny (2015b), Ghazy & Hefny (2017)], and they determine the travel time needed to transfer between each source and destination, these information is used to vehicle navigation.

At the emergency situations like occurrence of fire, flood or earthquake or other emergency, the data about that will be registered in emergency management application. The emergency management system deals with natural hazards that can happen in the natural surroundings as a result of hydrological, meteorological, seismic, geological, volcanic mass-movement or other natural processes that can cause a danger to communities and populations Qureshi & Abdullah (2013). This system has two main functions the first is, enable the traveller to notify appropriate emergency response, and the second is Emergency vehicle management Mathew (2014), however the data of the emergency occurrence like location and its effect on the road is very important for the dynamic routing system. In Ghazy & Hefeny (2014) it was proposed an architecture for a dynamic routing system that include emergency reactive controller, to be used at the emergency situation to preventing vehicle from routing through the emergency areas, see Fig.2.

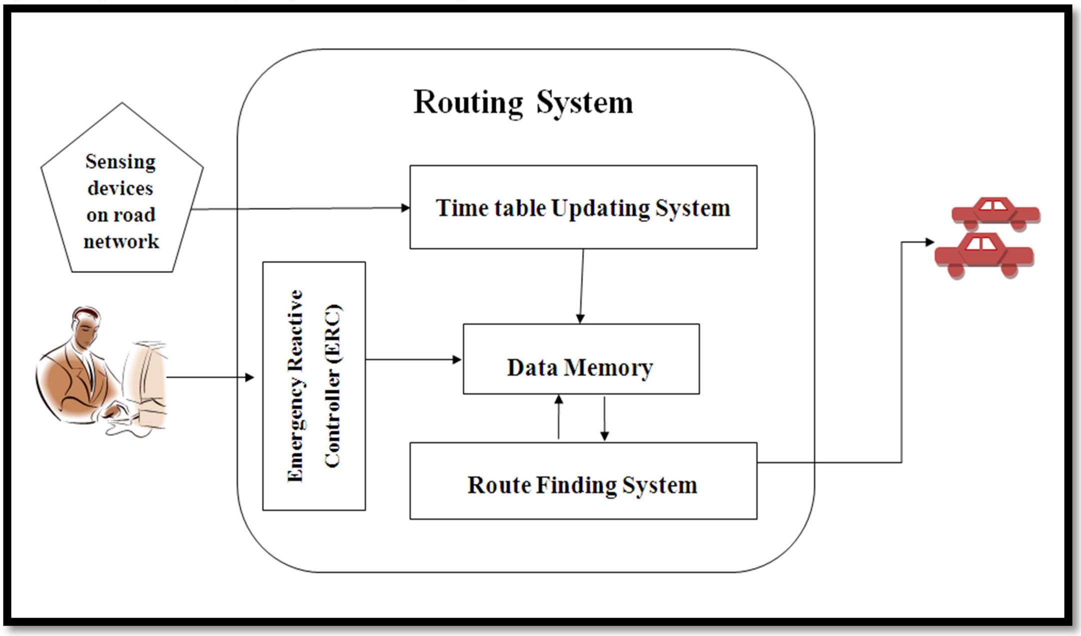

Fig. 2: Dynamic vehicle routing system with ERC
(Cited of [Ghazy & Hefeny (2014)])

The using of the emergency data by the emergency reactive controller, will preventing vehicle from entering the emergency area, this will enhance the performance of the routing system, but at the same time its good impact will reflect on the emergency management, because the preventing of directing vehicle to the emergency area will help in finishing the emergency situation vastly.

<u>Receiving data from other systems:</u>

- The data of accident is registered in accident application, which includes the location and the degree of dangers, when the effect of accident is removed from road, these type of data is very important for the Dynamic Traffic Routing as this data is itself acts as a type of emergency that required an evacuation around the area of accident.
- The data of current maintenance on Roads is registered in a road maintenance system, the data like the location of maintenance and the closed lanes, will affect the capacity of the current road or in some case it require closing some links of the road, such data is very important to be passed to the Dynamic Traffic routing System to decrease or prevent vehicle from directing through the maintenance area, and by this way it avoid the occurrence of congestion around this area.

<u>Produce data to serve other systems or Statistics:</u>

- Planning and modeling systems
  Applying fine tuning and using a layer of zoning system of the country, this information can be used to produce the skim matrix (distance, travel time) between the zones.
- Obtain important Statistics from systems, instead of doing Survey

The registered requests from the vehicle, to return the good route to special destination, can be used as a sample data to return the distribution matrix of trips between zones. Also by registering of vehicle type, and the knowing the zoning system and the car ownership by zone, the sample matrix of trip distribution can be statistically converted to a matrix represent all the population.

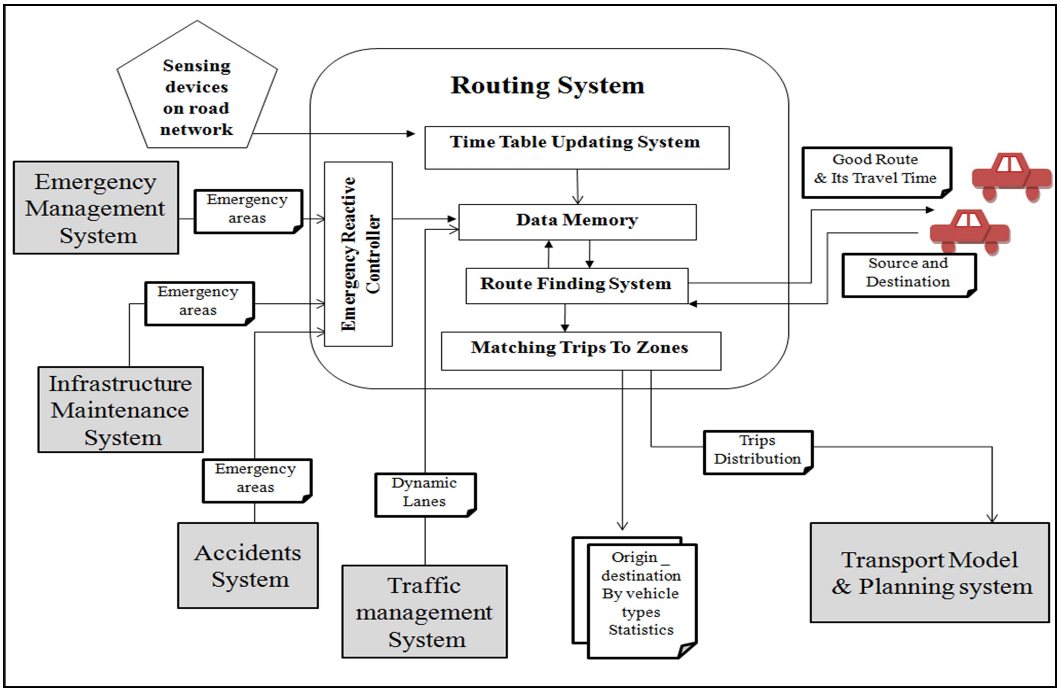

Fig. 3: The Interaction between Dynamic Routing System and other Transport Systems

Electronic Payment Systems

Electronic payment systems are used for collection of transit fares, highway tolls, and parking fees. Electronic payment saves the transaction data which can be used by different ways, transaction data are used to reconcile internal agency accounts. Transit fare payment systems used for provide increased convenience to customers and saving costs for transportation agencies and improving administrative controls. A transit fare payment system can be integrated across multiple transit agencies, becoming part of a regional fare payment system.

However this data is very useful for transport planning, it can be used after fine processing to produce the following:

- A public transportation matrix
  That includes the actual number of trips (for each transportation mode) between each source and destination, during different periods of years. The public transportation matrix is very important for Transportation planner, and in most cases planner can use a costly survey to prepare this matrix, with a high cost and a low accuracy than that extracted from the electronic payment system.
- Traffic counts per vehicle types at the high way toll stations
  This data is very important for calibrating the transportation model, which used for planning of road network.

4. Conclusions

This paper presents architecture to deal with a big data of transportation systems, and show how the cooperation between different transportation systems can be a useful way to maximize the use and benefit of each system in serve other systems. We can conclude that by using this architecture many required data of transportation systems can be periodically extracted from other transportation systems, which mean that a more accurate and real time data can be acquired by a minimal costs, therefore a suitable actions and decision can be taken depend on accurate data, also the use of survey can be minimized by this way of cooperation between different transportation systems.

References

McAfee, A., and Brynjolfsson, E. (2012).Big Data: The Management Revolution, Harvard Business Review 90:60– 68.

Mayer-Schonberger,V.&Cukier,K.(2013). Big Data: A Revolution That Will Transform How We Live, Work, and Think, Houghton Mifflin Harcourt, 2013.

Mathew, T. V. (2014). Transportation system engineering book. IIT Bombay, chapter no. 48, intelligent Transportation System, pp. 48.1.

Claes, R., &Holvoet, T. (2011). Ant colony optimization applied to route planning using link travel time predictions. In Parallel and Distributed Processing Workshops and PhD Forum (IPDPSW), 2011 IEEE International Symposium. (pp. 358-365). IEEE.

Claes, R., &Holvoet, T. (2012). Cooperative ant colony optimization in traffic route calculations. In Advances on Practical Applications of Agents and Multi-Agent Systems (pp. 23-34). Springer Berlin Heidelberg.

Boehlé, J. L., Rothkrantz, L. J. M., & van Wezel, M. (2008). CBPRS: A City Based Parking and Routing System (No. ERS-2008-029-LIS). Erasmus Research Institute of Management (ERIM), Erasmus University and the Erasmus School of Economics (ESE) at Erasmus University Rotterdam.

Ghazy, A. M., &Hefny, H. A. (2014). The Proposed Emergency Reactive Controller (ERC) Architecture for TAntNet Traffic Routing of Road Network", 49th Conference on Statistics, Computer Science and Operations Research (SCSOR49).

Ghazy, A. M., &Hefny, H. A.(2015a).Improving the Performance of TAntNet-2 by Using Multi Forward Scouts", The 10th IEEE International Conference on Computer Engineering and Systems (ICCES 2015), IEEE.

Ghazy, A. M., &Hefny, H. A. (2015b). Enhancing the Intelligent Transport System for Dynamic Traffic Routing by Using Swarm Intelligence. 50th Conference on Statistics, Computer Science and Operations Research (SCSOR50).

Ghazy, A. M., & Hefny, H. A. (2017). TAntNet-4: A Threshold based AntNet Algorithm with improved Scout Behavior. In A.E. Hassanien et al. (Ed.), Handbook of Research on Machine Learning Innovations and Trends, IGI Global, approved, under publication.

Khan, N., Yaqoob, I., Hashem, I. A. T., Inayat, Z., Mahmoud Ali, W. K., Alam, M., ... &Gani, A. (2014). Big data: survey, technologies, opportunities, and challenges. The Scientific World Journal, 2014.

Al Nuaimi, E., Al Neyadi, H., Mohamed, N., & Al-Jaroodi, J. (2015). Applications of big data to smart cities. Journal of Internet Services and Applications, 6(1), 25.

Qureshi, K. N., & Abdullah, A. H. (2013). A survey on intelligent transportation systems. Middle-East Journal of Scientific Research, 15(5), 629-642.