Integration of data in traffic control systems

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Abstract. *For the traffic experts to be able to correctly assess the condition of the controlled segment of a traffic system numerous data from various sources need to be collected, and then integrated, presented and analyzed in adequate space-time context.*

The integration of the collected data into a common entity accelerates the processing of data, analysis and presentation of the conditions of the controlled part of the traffic system. Therefore, the need for certain data has been defined, such as: traffic density, travel time component (waiting, walking, ride, etc.), meteorological data / parameters (air temperature, precipitation volume, fog and dew, storms with hail or strong winds), visibility, time of day (night, day), condition of the traffic network and others affecting the condition of the traffic infrastructure and functioning of the traffic system.

Keywords. traffic control, data, integration, encapsulation

1 Introduction

With the increase in the number of users and the acceptance of a host of activities from its immediate surrounding the traffic system has become a very complex and dynamic system that has to be continuously controlled. The dynamic nature of the system in which numerous parameters vary constantly, requires the traffic experts to provide solutions that will enable fast and simple insight into the system states in the past, in the present, and the quality of the collected and processed data has to ensure the possibility of estimating the condition in the future. The control of only one intersection can represent a challenge due to the large number of pedestrians, vehicles, road conditions, weather conditions, traffic condition on the surrounding roads (traffic networks) and the system in general. There are practically no parameters that do not change over time, and the changes, when they occur, can be sudden and quickly result in congestion, incident situation and human, material and financial losses.

The development of technical means that are used for the control of transport systems have enabled very fast and relatively simple collection of numerous data regarding the controlled segment of the traffic system. A greater problem lies in the organization, storage, analysis and correct interpretation of all the collected data.

All the collected data have to be placed into a common space-time context since there is little use of the data if they are collected at different times and in different conditions or if it cannot be determined who collected them, when, where, and how.

2 Data collection

Due to the availability of equipment and technical aids, data collection on the status of the traffic system does not represent a big problem since high-quality surveillance cameras are available on the market (stationary and mobile video systems), traffic radars and sensors, induction loops, light beams, digital motion detectors and other surveillance equipment. There is greater challenge in adequate organization of the collected data so that the traffic experts could make a fast and correct interpretation and analysis of the collected data.

Data from various data sources collected at the same time at the same place (i.e. in adequate space-time context) can be considered as a common set of data that describes the condition of the controlled segment of the traffic system.

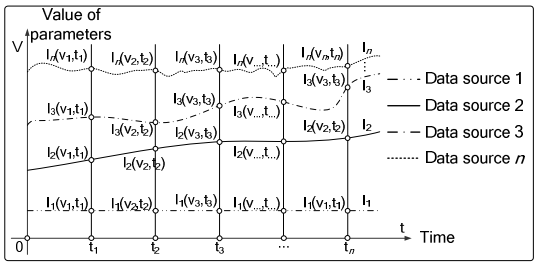

Figure 1. Values of parameters of data sources in the observed time segment

The collected data on the condition of the traffic system have been primarily determined with several basic properties:

- space in which the data on the traffic system condition have been collected;
- time in which the data on the traffic system condition have been collected (time intervals);
- sources of data on the traffic system condition;
- technical means and the technology used for data collection;
- organization and saving of the collected data.

Only after having defined the basic properties i.e. data sources it is possible to start collecting, processing and analyzing the collected data and to make conclusions on the condition of the controlled segment of the traffic system.

The selection of data depends on the need at a certain location i.e. traffic system segment, and with the aim of future research at the Faculty of Traffic and Transport Sciences the following would be used:

- data from the surveillance camera (visibility, light depending on the time of day), example presented in Figure 2;
- radar data;
- GPS data;
- meteorological data/parameters (air temperature, amount of precipitation, fog with hail or strong wind, number of sunny hours during the day, volume of precipitation per day, time of sunrise, time of sunset);
- data from the detector/traffic count (roads, entries/exits from the city, main traffic flows, parking-garage facilities);
- data on traffic density;
- time component of travelling (waiting, walking, ride, etc.);
- condition of traffic network and others that influence the condition of the traffic infrastructure and functioning of the traffic system.

Space in which the data have been collected is determined by the traffic system segment which needs to be controlled over time. The selection of the number and type of data sources is defined by the traffic expert in accordance with the needs and condition of the controlled traffic system segment.

The increase in the number of sources regarding data on the traffic system condition can give a better idea about its condition, but their proper functioning and maintenance require the provision of additional material and financial resources.

The control is usually performed by using surveillance cameras, traffic radars, adapted sensors and other control equipment that is available to the traffic expert.

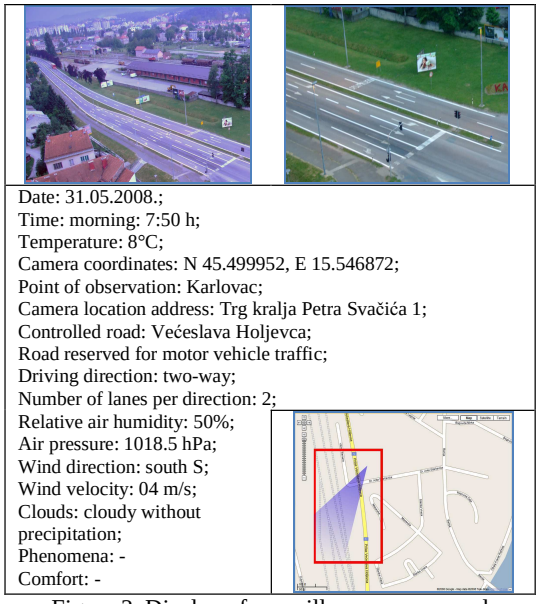

Figure 2. Display of surveillance camera and meteorological data[1]

The collected data from all data sources have to:

- have strictly defined format of records and organization of the collected data;
- be saved in digital form in order to facilitate their determination, manipulation and saving on the computer.

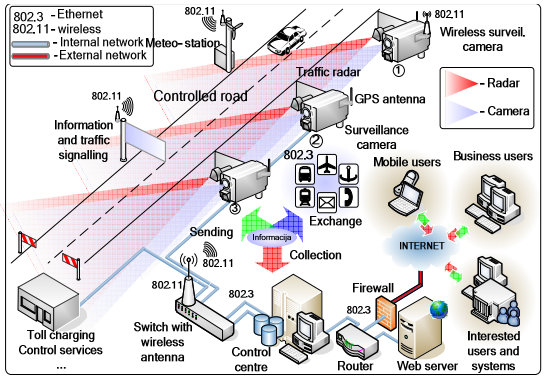

Figure 3. Road control system

[1] http://maps.google.com/maps/mm?f=q&hl=en&geocode=&q=karlovac&ie=UTF8&t=h&ll=45.498876,15.548127&spn=0.002538,0.004699&z=18

Because of the digital record of data, the collected data are more exposed to misuse and it is therefore necessary to provide safety mechanisms that will ensure integrity and credibility of the collected data.

An example of a table of collected data from a certain location is presented in Figure 4.

Surveillance Video	
Date of rec.: 10.10.2007	
Time of rec.: 07:15:44 PM	Frame No.: 15522
Camera ID : CAM:FPZ-KA	Clip No.: 15
Frame Hash: 4524F2ACC5047B526A1129E	
**********	
Traffic Radar	Statistics:
Radar ID : 511:FPZ-KA	Time range: 08:00 AM – 08:00 PM
Location: Karlovac, HR	Date range: 10.10. – 10.10.2007
Date/Time: 10.10.2007 / 07:15:44 PM	
Street : Trg K.P. Svacica 1	Min rec. speed: 25 km/h
Capture Zone : Entire street	Max rec. speed: 70 km/h
Radar Heading: 216	Avg rec. speed: 38,9 km/h
Speed Limit: 50 km/h	Last rec. speed: 48 km/h
Types of Vehicles : All	No. of Vehicles: 481 (100%)
Direction(s) : Approaching	No. of Veh. in limit: 337 (70%)
Weather Conditions: Good	No. of Veh. over limit: 144 (30%)
**********	
Meteorology	
Station ID: MET:FPZ-KA	Temperature: 12 C
Location: Karlovac, HR	Pressure: 990 mb
Date/Time: 10.10.2007	Wind spd: 1 m/s
Time: 07:15:44 PM	Wind direction: NE
Visibility: Moderate	Humidity: 60%
	UV index: ---
**********	
GPS	
GPS ID: GPA:FPZ-KA	Latitude: 45° 29’ 34” N
Location: Karlovac, HR	Longitude: 15° 33’ 31” E
Date/Time: 10.10.2007	Altitude: 112 m
Time: 07:15:44 PM	
**********	
Camera	
Camera ID : CAM:FPZ-KA	Zoom: 1,0x
Location: Karlovac, HR	Resolution: 1024x768
Date/Time: 10.10.2007 / 07:15:44 PM	Frame rate: 12 FPS
Camera Heading: 216	Mode: Day
Field of View: 35 mm	Output format: MJPEG
**********	

Figure 4. Table of collected data from a certain location

3 Integration of collected data

If the collected data on the condition of the controlled traffic system segment are considered independently, then they yield a limited image of the state and conditions so that it is necessary to somehow adapt all the data in order to observe them simultaneously in identical space-time context.

Integration of data can be performed in two ways:
- saving of data into the database;
- encapsulation within header data.

Regardless of the selected method of integrating the (collected) data the following has to be ensured:
- equipment, instruments, professional staff, and other material resources;
- adequate computer and software support;
- adequate information and telecommunication infrastructure;
- technical staff providing software and computer support;
- traffic experts for proper interpretation of the collected data;
- possibility of presenting the collected data to the users and systems.

3.1 Integration of collected data within the database

Saving of data in the database is a well-known, developed and widespread method which features the following characteristics:
- developed and well-documented procedure of data saving;
- large number of different databases, auxiliary tools and users;
- developed computer and software support;
- simple database management by means of graphical interface;
- simple isolation of a part of data and their export into independent data;
- simple maintenance of the database of local and remote users;
- automated input of the collected values (in the form of formatted text) into the database;
- generating of a file with a list of all activities so that it is possible to monitor all the activities and changes in the database (file log);
- fast manipulation of large amounts of data;
- robustness of the base and the saved data;
- installed management of users rights;
- fast and simple archiving and restoring of data;
- encryption of sensitive data;
- standardized interface for the generation of enquiries and producing reports;
- generation of complex reports from several databases;
- it is necessary to indicate precisely which data are to be interrelated and under which conditions;
- standardized interfaces for the connection with other databases and applications;
- possibility of access from remote users (Web interface, 3-tier applications);
- data in databases may be spatially located elsewhere.

The development of databases started already at the very beginnings of the computer technology development. Over time, many commercial as well as open-source databases have been developed, which allow the processing of huge amounts of data, and sufficiently robust to maintain the data integrity in damaging the base structure, having their own data protection systems, developed graphical interface which makes them extremely user-friendly and

facilitating maintenance and administration. Various methodologies of processing, preparation and data search have been developed, and the standards have been formed that allow fast and simple sharing of data with applications and other databases.

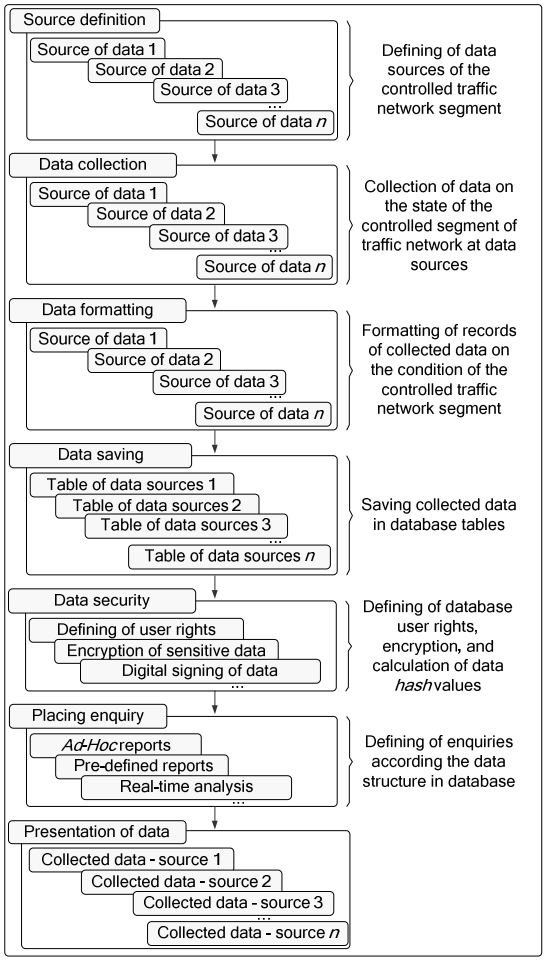

Figure 5. Collecting and saving data of the traffic system into the database

3.2 Integration of collected data by encapsulation

Integration of data by encapsulation within the header data is less known and for the moment insufficiently studied method of data integration. It is first of all necessary to select one type of data within which other collected data will be saved. The condition is that during encapsulation there should be no damaging of the header data and the data inserted within.

The encapsulation procedure has to be reversible – the inserted data into the header can be isolated and presented individually.

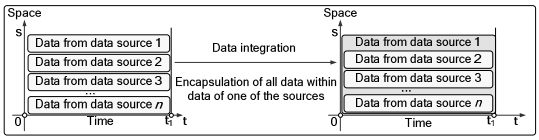

Figure 6. Encapsulation of collected data

The characteristics of the encapsulation method are the following:

- insufficiently studied area and few users;
- there is no standardization regarding the structure, algorithms or methods of data encapsulation;
- there are different and mutually incompatible software solutions;
- every software solution has its own data structure;
- the sensitivity to small changes or deformations of header data;
- management of users rights (for the moment) is not independent but rather based on the possibilities of the operative system;
- possible fast and simple compression, encryption and digital signature which yields integrity and credibility of data;
- the collected data can be isolated from the header and input into the database;
- there is no standard interface towards the databases;
- simple archiving, compressing, and restoring of data (header data with encapsulated data);
- undisturbed independent usage of header data without using the encapsulated data;
- the confidentiality of encapsulated data is ensured since the encapsulated data are not visible in any form when header data are used;
- by encapsulating the characteristic data it is possible to authorize the header data (watermark);
- manipulation of header data results in damaging of the encapsulated data which may discover the data manipulation, but not what disturbed the data integrity;
- easier consideration of the entire controlled situation since all the data are unified and have a common space-time context;
- all the data are at one place and cannot be dislocated (since this would disturb the integrity of the collected data).

It should be noted that the header data and other data (which are to be encapsulated) have to keep their own integrity, form and contents in spite of the fact that the data are interconnected and integrated into one whole.

The encapsulation procedure is performed according to the exactly defined algorithm in order to be able to restore the encapsulated data into the original form without losing integrity and contents.

For successful encapsulation procedure the procedures of compression, encryption and digital signing are not necessary but can be used in order to additionally protect the collected data and in order to ensure their integrity and credibility.

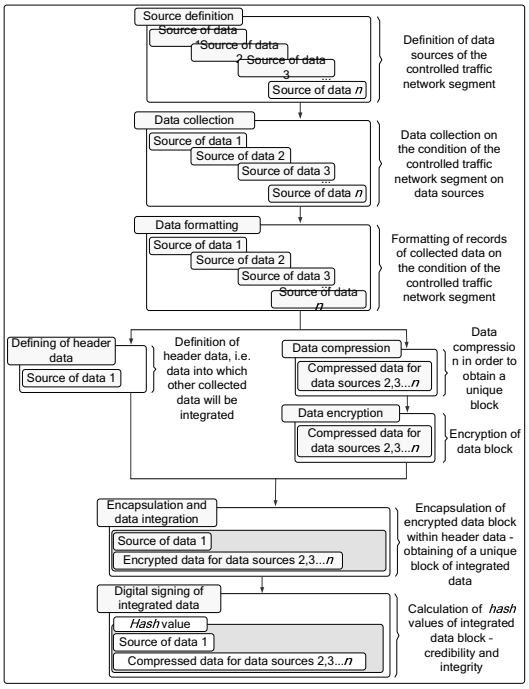

Figure 6. Collecting and saving traffic system data by encapsulation

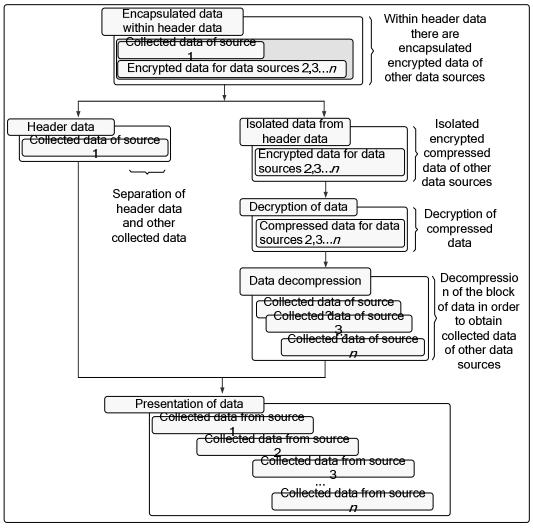

Figure 7. Separation and presentation of the collected data of the traffic system by encapsulation

The encapsulation process ensures another very important property – data confidentiality. If the data are encapsulated within the header data then they will be invisible to the observer. The best known and most widespread data protection procedure is data encryption. The encryption does not ensure the confidentiality since anyone having the encrypted dana knows that they hide the original data, but in case of data encapsulation the observer does not have knowledge about the presence of the "hidden" data. This feature can be used as additional protection of data integrity. Within the header data it is possible to integrate additional control data that will serve as a kind of a digital watermark. Any unpermitted manipulation results in damaging the digital watermark (i.e. encapsulated control data) which is a clear indicator of the disturbance of integrity and credibility of data.

4 Conclusion

The collected data of the traffic control system have to be organized in an adequate way so that the traffic experts can see fast and simply how the controlled traffic system segment functions as well as its condition. Because of the complex structure and a large number of interrelations, relations, activities, processes, limitations, objectives and elements, the collected data should not be observed as isolated and independent situations of the traffic system segment, but rather all the collected data have to be always observed at the level of the entire traffic system and at the level of the surrounding systems whose functioning depends on the stable functioning of the traffic system.

In order to allow fast and efficient analysis of the collected data, it is necessary to integrate them, and in using the method it is necessary to take into consideration a number of facts such as: insurance of adequate infrastructure and software and professional support, the end form of all the collected data has to be in the digital form; to allow the integration of the collected data into the database or using encapsulation of data within the header data without losing their contents, form and quality.

All the collected data have to be in the appropriate space and time context, insuring the security of the integrity and credibility of the data in both methods. During processing, integration and saving there should be no damaging of data, and regardless of the intensity or the amount of data every manipulation of the collected data has to be detected.

The presented integrated data have to fully match the collected data and the presentation of these has to be clear and unambiguous. The standardization of the integration method is possible either in the form of database or encapsulation, and the collected data can be integrated parallel in both ways in order to use all the advantages provided by a single method.

The data encapsulation method has not been sufficiently studied and there are no precisely defined methodology and standards, unlike integration of the collected data within the database.

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