Modelling of System for Transport and Traffic Information Management in Republic of Croatia

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1. Introduction

The traffic system is expected to provide faster, safer, more reliable, more comfortable and less expensive movement with enabling of maximal personal mobility. One of the necessary preconditions to realize these expectations is the real-time information of all those participating in the traffic processes with all the relevant data. Consequently, it is necessary to design and construct a traffic system that will, with the application of advanced information communication technologies (ICT), insure the backbone that will integrate the users' services based on the principles of intelligent transport systems (ITS), in order to be able to provide the system users with reliable, precise and timely information necessary for a more efficient realization of the transport process.

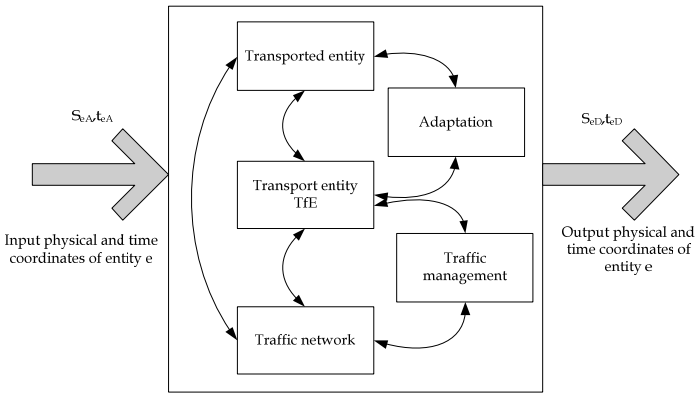

Fig. 1. Generalized model of the traffic system

With the application of modern ICT, the system for traffic information management collects, performs the adaptation process, fusion and processing (verification and addition of weights to each collected information) and carries out the distribution to all the interested users. Thus, new services may be offered that directly contribute to the improvement of traffic system quality by improving the change of space – time (s, t) coordinates (Figure 1) of the transported entity which is transported or transferred in adequate transport entity and

moves with it along the transport network, with better efficiency of the consumed energy and less polluted environment.
The application of terminal user equipment and the developed program package adapted to single users and terminal equipment, allows input of information on the events by the information source or their request for certain information. The system implies the implementation of services of advanced fix and mobile communication systems, and naturally the Internet. By implementing separate modules it will be possible to process different input information received by WEB provider, WAP protocol, E-mail and SMS/MMS messages and the so-called CALL centre. With the previously mentioned communication technologies, RDS-TMC technology for user information by means of radio receiver can be applied in the distribution of data.
The information service providers can use output data from the system for traffic data management and thus expand their activity or be exclusive suppliers of traffic information with or without added value. Based on this, with intermodal pre-travel and on-travel informing of the traffic system users, significant improvements can be achieved in dynamic vehicle fleet routing, forecasting of travel time, etc.
Modern mobile communication systems offer services which allow realization of real-time informing of all the traffic system users, with the possibility of realizing financial profit of the system for traffic and transport information management (STTIM). Different business models of operation STTIM operation will attract a large number of those interested in performing this, until now in the Republic of Croatia (RH) unrecognized activity.

2. Assumptions for the application of ICT and ITS technology in the traffic system of the Republic of Croatia

Modern traffic system needs to be planned and expanded according to the principles of intelligent transport systems in order to take advantage that such a system can insure.
Intelligent transport system means the implementation of new ICT and sensor technologies in traffic and transport in order to improve the quality of traffic, transportation and transport for all participants in the process. ITS is a system that provides services to the users by means of the distributed information system using user-friendly interfaces, either in private or public sector. ITS is adaptable and open, on the one hand it offers the implementation of different technologies of interactive and multimedia characteristics, and on the other hand it guarantees full action on the entire area, from the micro location (streets, city), to regions, nations and the world as a whole.
The efficiency of the traffic system is an extremely important element of the strategic planning in which two complexes of indicators are distinguished: quality and productivity on the one hand and allocation and environmental dimension on the other. The mobility that does not meet the additional requirements of allocation and environmental efficacy i.e. which does not cover entirely the external (social) costs, is considered as unefficient.
ITS implementation in the Croatian traffic systems results in higher satisfaction both of the national population as well as the visitors, business people or tourists, i.e. in overall prosperity of the environment. The ITS role in the development of the transport of goods and services, especially tourism as one of the most perspective export products, has strategic importance of the highest level.
Obviously, modern approach to the development of the traffic systems places the emphasis on the raising the level of safety and security of the traffic system users and on the more

efficient transport network. The above mentioned has to be supplemented by the solutions that will contribute to national security, the more so since at present the malicious activities are frequent worldwide, directed to disturbing the national security, by disturbing the security of the traffic system users.

The national ITS architecture should provide a general orientation in order to provide compatibility / interoperability of the system, products and services, without restricting the provided options. It gives us a common structure of developing intelligent transport systems. This is the frame around which multiple approaches to the development can be developed, out of which each one is specifically adapted in order to satisfy the individual needs of the users, at the same time keeping the advantages of common architecture. ITS is expected to be capable of action, as well as of the growth, regardless of the change in operation, organisation or technical conditions. The basic precondition that has to be insured is the system standardization, from the layer of architecture concept (i.e. referent model) to physical implementation.

The purpose of defining ITS architecture is to establish an integral architecture of the system so that individual components represent the subsystems which are used to realize the set objectives of ITS, at the same time supporting the necessary range of services, with compatibility and interoperability at all state levels. The possibility will also be provided to expand and modernize the system at affordable costs.

In defining ITS architecture it is necessary to take into consideration the following features:

- structure modularity in such a way that the functions of user services can be distributed to subsystems;
- transparency of data in relation to subsystems and services;
- standardization of mobile users interfaces, in order to realize the integrity of the services as part of an integral national and international system;
- the possibility of implementing the system in the existing traffic and telecommunication infrastructure, with the possibility of upgrading by new technologies;
- structural characteristic of the architecture enabling the implementation of a wide range of communication and information systems and protocols;
- the flexibility of the system architecture by being able to adapt to centralized or decentralized activity in order to meet different functions, different preferences and different strategies of supervision and control.

Regardless of the methodology which is used to construct the ITS architecture, the following models are used for the start:

- logic, and
- physical architecture.

Logic architecture represents the functional aspect of ITS user services. This aspect is separated from the possible implementations and requirements of the physical interface. It defines the functions or specifies the processes that are necessary to perform ITS user services and flows of information or data that need to be exchanged between these functions. The logic model is the basis for the definition of the physical architecture which can be used as the basis for the construction of the system. It is independent of the implementation and physical requirements of software and hardware. The logic model defines first of all the functions that need to be supported in order to realize the ITS user services, as well as the model of information and data exchange between these functions.

The physical architecture presents how the system will perform the defined functions. It can be divided into transport and communication subsystem that connects the transport layer elements.

3. Model of information management for the traffic system users

Over time it became obvious that some of the originally defined ITS user services were too wide in scope to be suitable for the planning of actual implementation. Therefore, a finer classification of ITS services known as "market packages" has been defined. They are harmonized so as to correspond individually or in combination to problems and needs of the transportation and transport in the real world.
Since even this finer classification of services is rather inflexible and rigid, the work presents a new model of traffic information management for the traffic system users that is based on the analysis of international experiences in the implementation of the current users services, the so-called market packages in ITS and the users requirements recognising the specific features of the Republic of Croatia.

3.1 The basic information requirements

The model predicts the meeting of all the basic requirements that refer to ITS (Federal Highway Administration, 2004), and were studied in detail in previous scientific and research works[1]. They define everything that is necessary for the configuration and realization of a reliable system that will provide the users with updated, precise and timely information.
The requirements set according to the model of information distribution to the traffic system users, i.e. the system for the management of information on the condition in the traffic system, which is based on the implementation of the developed model, refer to:

a. availability and quality of service;

Model of information distribution to the traffic system users should provide the backbone for the configuration and integration of the users services in order to enable:

- precise,
- reliable,
- safe,
- fast
    - delivery, and
    - exchange of information among the users,

timely (in real time) and in the economically justified manner.

b. interoperability of services;

The model has to enable interoperability of services regardless of the service provider involved.

c. continuity of service;

The backbone necessary for the continuity of the service between different service providers who offer the same or similar services needs to be insured.

d. growth, flexibility, and expansion of service;

[1] Refers to independent works or works co-authored by the author of this chapter, listed among literature

The system which applies the proposed model should support the growth, flexibility and expansion of the user services with interaction with the external service elements that do not belong to ITS. The system has to have the possibility of adaptation and implementation of the existing technologies and infrastructure to the currently existing and future ITS users services, as well as enabling the interaction with services that do not belong to the ITS services. It should also insure acceptable level of integration and continuity of operation.

e. unbiased services and support;

The model should insure unbiased provision of services and the pricing possibilities and information charge. A wide demographic segment of the society (senior people, the disabled, etc.) need to be included, as well as different geographic areas (urban, rural environments). The economic justified work and maintenance need to be supported in order to adapt it to the means of the service providers and the users' needs.

f. evolution and service;

The system should support the evolutionary nature of the users' services in order to be able to adapt to the improvement of the technology of transport and communication infrastructure, as well as the development of the means, partner arrangements of public and private sector.

g. variations in the configuration of services;

It is necessary to allow for variations in relation to the configuration of services, as well as the variations in the operation and the technologies. Also, mutual exchange of service components should be promoted (e.g. GIS maps, etc.) which has been provided by another producer.

With the abovementioned, the system for the management of information about the condition in the traffic system has to be modular, highly flexible for all the possible changes in it. Also, the principle of the availability of the equipment that is planned to be used has to be recognized, i.e. the price of the basic equipment necessary to use the new services has to be affordable in order to make the system accessible to a maximum number of users.

3.2 Presentation of negative characteristics of applying current methods of increasing the information level of traffic system users

This chapter focuses on the observed drawbacks of the existing information systems for the traffic system users with concrete examples in the city of Velika Gorica and the city of Zagreb.

The example in Figures 2 and 3 shows the information system intended for the citizens about the communal works in the city of Velika Gorica. Not only does the sticking of notices on the trees fail to comply with the minimal visual and ecological standards, this notice does not even show the complete text so that it is not clear whom the information is intended to nor is it clear what it is about.

Regarding the traffic flow within the traffic system, from this information it remains unclear whether the works will have impact on the undisturbed traffic flow at locations at which these are performed.

In order to contribute to the development of the traffic system it is necessary to develop a model whose application provides management of information about the condition in the traffic system (e.g. information on road conditions, traffic accidents, traffic congestions, bans, road works, etc.) to the interested and those participating in traffic flows. This is especially important for individual users since the application of the model contributes also to the overall satisfaction of the users.

Fig. 2. Example of informing the citizens about the works and their influence on the traffic flow (city of Velika Gorica)

Fig. 3. Example of informing the citizens about the works and their influence on the traffic flow (city of Velika Gorica)

Often, during big traffic jams, dissatisfied users can be encountered who make attempts to solve the traffic problem by themselves, which almost always results in an even greater problem. Figures 4 and 5 show the behaviour of motorists dissatisfied with the condition in the traffic system of the city of Zagreb.

Fig. 4. Example of the behaviour of citizens in traffic (city of Zagreb)

Fig. 5. Example of the behaviour of citizens in traffic (city of Zagreb)

3.3 Existing information systems

Not one of the currently available systems for information on the condition in traffic in the Republic of Croatia supports the users' requests for high quality of information, updatedness (high updating frequency of the actual information), simplicity of access (e.g. by implementation of the developed applications for mobile terminal devices), simplicity of searching real-time information, etc.

There are several providers of information on the traffic conditions, but all of them act within isolated areas of interests or they take over the information from the Croatian Automobile Club (Hrvatski autoklub - HAK) that provides information via Internet server, with textual information on the traffic condition and the possibility of displaying video-recordings of certain critical points at certain sections. This causes high redundancy and availability of old, no more actual information on the traffic condition.

Other subjects that have some information on the events in traffic (e.g. floods, traffic accidents, roadworks) publish these isolated and distribute them by radio broadcasts, web portals, etc. The numerousness of such portals confuses the potential users and questions the quality and updatedness of the published information.At the moment there is no unique portal in the Republic of Croatia that would serve for the purpose of managing information about maximum number of events that may affect the traffic flow.

The model resulting from this work provides the basis for the implementation of such systems for traffic information management (STTIM) that as the product of this work would generate and distribute the information on the traffic system included in the traffic flow, in order to improve their operation and travelling along the network.

For instance, the service of automated informing of the car motorists that they are approaching a section of the road covered by ice is not a service for the users of mobile communication systems and LBS-based but rather the so-called VMS (*Variable Message Signs*) traffic signs along the road. Although the section manager has such information, there is no developed system of distribution by means of SMS, TMC/RDS or the developed applications for terminal devices.

Currently there is a series of services that are not available in the Republic of Croatia and that the foreign users have learned to use in the countries they come from, e.g. in the area of tourist information, and the application possibilities studied in the past research by the author of this work. The additional functionality, namely, with the aim of better and enhanced information of users regarding tourist resources, is the information of the users about other facilities and activities, and full personalization of the services on the basis of users' habits. The user, i.e. the tourist staying in Croatia can obtain information about the requested tourist resources in their vicinity shortening thus the path through the traffic network and the time required otherwise to arrive to the concrete object (Peraković, Jovović, & Forenbacher, 2010).

Mobile information and communication technology determines the society and methods of behaviour since it represents a component of the personality and method of communication and operation. The potential provided by the hardware can be fully used only be adjusting to the users' requirements, by improving the software part. Modern applications have to provide the user with what they want, anywhere they want it and in the best possible way, and one of the examples is also the reminder based on the location of the user (LBS – location-based service) such as the GpsALARM application (Peraković, Remenar, & Husnjak, 2011).

It should be emphasised that the realization of a wide spectrum of services in ITS means the implementation of modern computers, sensors and communication systems. Therefore, especially important is the telecommunication infrastructure which is responsible for the ensurance of maximum distributed backbone for interconnection of terminal equipment, signaling and sensor equipment in buildings, control and information spots, as well as mobile terminals in vechicles and users in movement. Since the transport system of today cannot be imagined without information and managing systems that represent the backbone of traffic security and transport, risk management plays an important role in the development and management of all transportation systems. Identification of security risks is a process that allows quality and more cost-effective decision-making regarding the promotion and improvement of (Peraković, Kuljanić, & Šipek, 2011).

3.4 Types of information on the condition in traffic system included in the model

In order to contribute to the improvement of the traffic system, the information have to be provided for the traffic system users based on which they will be able to change from the classical sequential model of selecting the mode, route, and time of transport to a dynamic demand model.

The research in this paper is directed to the study of the source of possible impacts of, e.g.:

- incidents in traffic (traffic accidents, special transport, etc.),
- preventive and corrective maintenance of the network infrastructure (e.g. repair and asphalting of certain sections, cleaning of traffic lights, etc.),
- preventive and intervention/corrective maintenance that can have influence on the traffic flow (e.g. mowing the grass area along the road, maintenance of electrical, gas or telecommunication networks, etc.),
- planned events (e.g. soccer games, open-air concerts, transport and stay of protected persons on certain sections, etc.),
- weather conditions and weather forecasts,

on the traffic process, i.e. impact on the traffic flow along the network infrastructure.

The improvement of the existing routing systems of traffic entities along the network is possible if during the phase of interactive generation of new route plans by using heuristic methods the real-time traffic information about the potential routes are taken into consideration as well. Currently, directing of the traffic entities in the network is based either on the knowledge of the driver or the driver is left to rely on the navigation algorithms in determining the travel route. The travel routes are calculated by means of algorithms that do not take into consideration the current conditions on the roads but rather determine exclusively the shortest, simplest or fastest route. The real-time collection of data from traffic and the collection of data about the movement of each individual traffic entity (as sensor in the traffic network about the system condition) make it possible to obtain good information on the traffic condition. The mentioned information would be distributed by STTIM and they would be included in the advanced determination of routes in order to shorten the travel time, reduce road congestion, reduce the overall fuel consumption and reduce the pollution generated by fuel combustion.

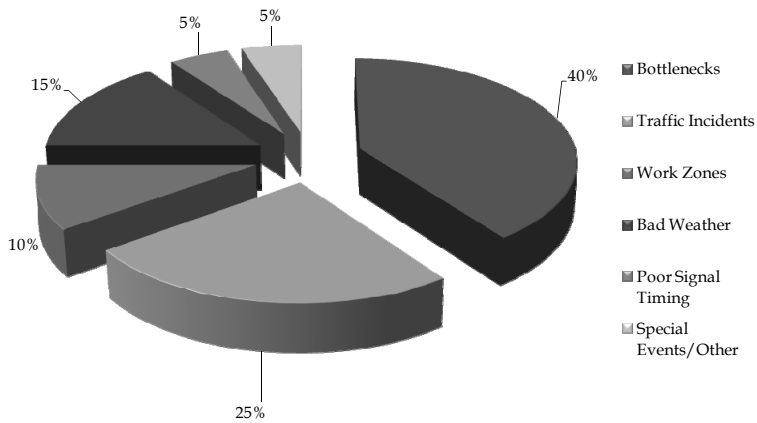

Fig. 6. Sources of traffic flow congestion

Numerous studies that have been carried out until now, have shown the impact of certain sources on the traffic flow congestion in the road (and urban) traffic flow (Cambridge Systematic, 2004). Figure 6 shows that the research scope of this work covers a significant part of potential sources of problems in road traffic. The scope of research that had not yet been covered by the actual version of the model forecasts further improvement precisely in this direction. The "bottleneck" problematic can be significantly reduced by better real-time information of the motorists based on the data collected by means of , for instance, sensors, cameras, etc. about the traffic volumes, traffic flow density, etc.

The up-to-datedness or time of information update about a certain event and the speed of receiving it by STTIM for further processing within the system is the basis for further information handling.

Based on the results of the research project Actual and Dynamic MAP for Transport Telematic Applications (ActMAP) Figure 7 shows the recommended frequency of information updates within the time frame of the observation (Dr. Bernd Thomas, 2007).

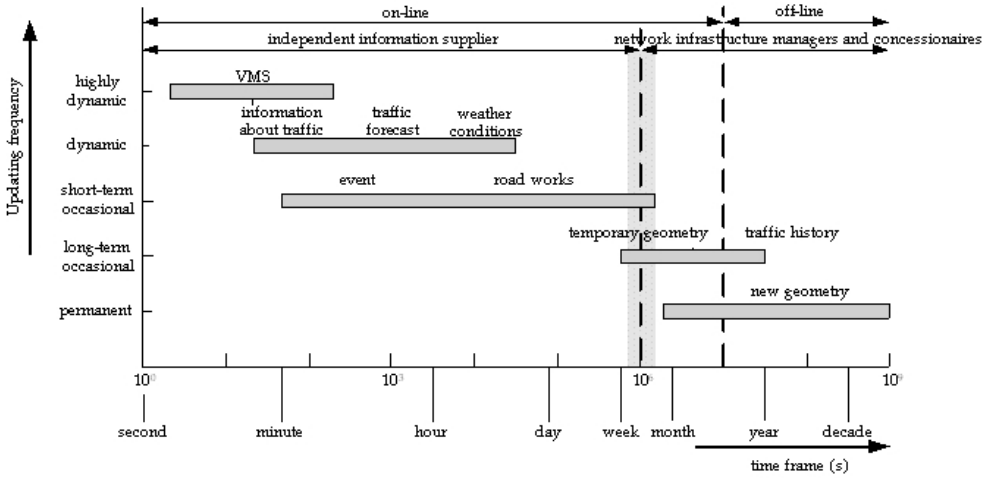

Fig. 7. Frequency of updating single types of information in relation to the time frames of observation

It may be observed that the information can be collected by independent suppliers, using online ICT technology in real time. The network infrastructure managers and concessionaires can use also the offline technologies in publishing individual, predefined and known classes of data, e.g. new road routes and archive data on the network traffic. For the temporary changes in geometry, online methods need to be implemented by all means. These methods mean the so-called internet business model as the most valuable and modern way of company operation.

Certainly, the time delay in the process of creating information within STTIM needs to be taken into consideration (collection, fusion, processing and distribution of information) that implements the developed application package IS STUP (Peraković, 2006). The time delay has been explained by Figure 8.

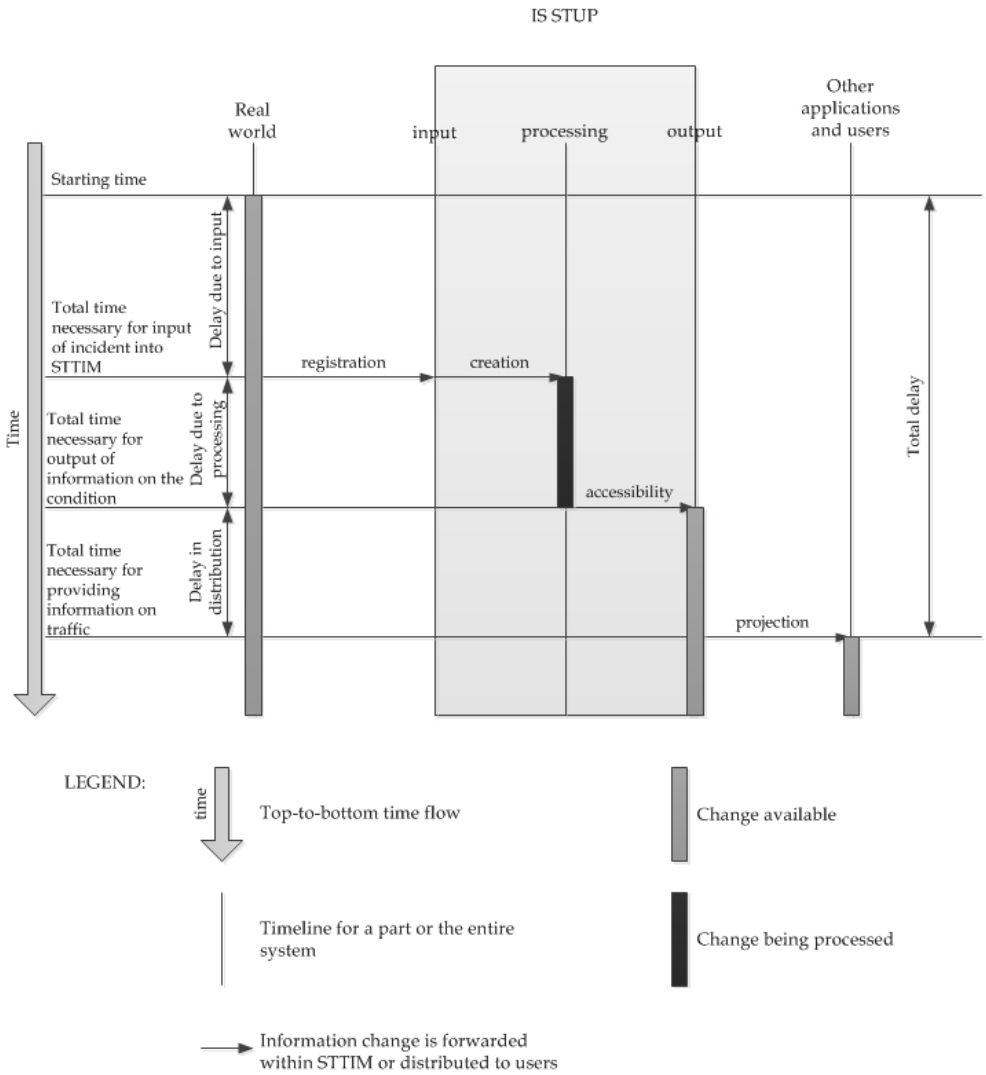

Fig. 8. Time delay in collection, processing and distribution of information

Further improvements of the proposed model need to be directed to research of the possibility of implementing advanced sensor technologies in collecting the traffic information, with emphasis on the information about the traffic flow. With certain adjustment for the adaptation of the input information and the implementation of these modules, it is possible to use the information about the traffic flow in the model of this work. The traffic parameters that the sensors need to collect are classified into two groups: traffic parameters for motorways and traffic parameters for intersections (Jelušić, Protega, & Carić, 2002).

The traffic flow parameters for the highways can be:

- intensity or volume of the traffic flow is the number of vehicles that pass the detection point within a defined time interval; usually expressed in the number of vehicles per hour (veh./h),
- average speed at the detection point is the average speed of all the vehicles within the defined period (km/h),
- occupancy is defined on a certain point, and it says how much time within the defined time period the vehicle physically occupies (covers) this point; expressed in percentages,
- the density of vehicles is the number of vehicles on a certain section of motorway and it is expressed in the number of vehicles per kilometre for every traffic lane (veh./km),
- presence (stopped vehicle) on the ramp (entry to motorway) has the value 1 if the vehicle is present and value 0 if not,
- the queue on the ramp says how many vehicles are waiting to merge the motorway traffic (vehicles) etc.

The traffic flow parameters for the intersection are:

- traffic parameters: intensity, average approach speed, vehicle density, vehicle presence, occupancy and classification are defined in the same manner, but for each approaching direction to the intersection and every lane,
- the length of the approaching queue is the number of vehicles waiting at the intersection for each cycle, for each direction, and each lane,
- the profile of the approach flow is the number of vehicles approaching the intersection in a group in every traffic lane, etc.

3.5 Potential information suppliers

The identification of all the potential users represents a precondition during the development of the model for data management on a modern traffic system. The users are selected in several classes. The problematic of identification of the potential ITS users can be found in several projects in Europe and in the world.

According to guidelines resulting from the CONVERGE (*Telematics Sector Consensus and Support Project*), the potential users of ITS services are classified into four main categories (Jesty, 1998).

These are the users who:

- want ITS systems, that will solve (or reduce) the traffic problems, or supply with traffic information the information management system about the state in the traffic system STTIM;
- build ITS systems, such as: system integrators, transport means manufacturers, telecom operators, information service providers, etc.
- use ITS systems, such as:
  a. primary users, who will benefit from the useful information generated by ITS by its operation (commuters, business users, users out of entertainment and fun, travelling salespersons, passengers with special needs, etc.), and
  b. secondary users (traffic controllers, emergency services, etc.) control the ITS system and provide a part of input data in ITS.
- define ITS and manage it (municipal, local and national authorities that are responsible for regulating the regime according to which the system will be implemented and used).

The research on the possibilities of implementing mobile Internet in intelligent transport systems (Peraković, 2003) and on the basis of KAREN's (*Keystone Architecture Required for European Networks*) (Bossan, 1999) project and ITSWAP (*Intelligent Transport Systems Over Wireless Application Protocol*) project, have resulted for the needs of the operation of the model from this work in the classification of the potential STTIM users in Croatia into eight initial classes.

By experimental implementation of the allocation IS STUP package, and additional analyses and continuous research of the users' requests and the satisfaction in experimental work, taking into consideration the specific characteristics of the Republic of Croatia as a transition country, and based on the recommendations issued by US DOT (*US Department of Transportation)* expressed in the development of national ITS architecture(Architecture Development Team, 2007), a new and expanded identification of potential STTIM users divided into nine categories has been made. Detailed identification of the users is a necessity in order to be able to form the weight value (ponder) in the development and implementation of the model, which is used to estimate a certain source of information and the quality of the information itself.

Figure 9 shows the classification of users in institutional, transportation and communication ITS layers.

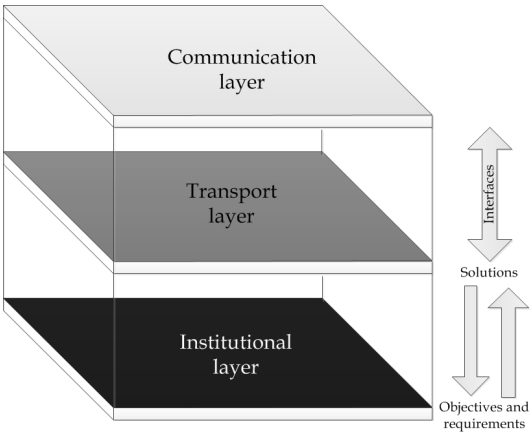

Fig. 9. ITS layered architecture

Institutional element reflects the borders of authorities (city, county, state and government offices, public institutions) and organization borders within the authorities, and includes private companies, public-private enterprises and public enterprises. This element insures financing for the performed users' services. Every authority (jurisdiction) and organization needs to determine which services should be offered and at what cost. Private companies can offer services that can exceed the jurisdiction borders regarding the market influence.

Consequently, the users can be classified into:

- Government administration and public institutions

In compliance with the Constitution of the Republic of Croatia and the regulations on the organization of work of the government bodies the users can be identified such as government administration, county administration, district and municipal authority as well as institutions in city areas.

They plan, manage and regulate traffic transport needs in their limited area, and for the performance of these activities they use, and during work generate information on the condition in traffic within a limited area.

- Providers of information services and traffic-related contents

In the Republic of Croatia there is an increasing problem in the numerousness of the information about the condition in the traffic system (Peraković, Protega, & Jelušić, 2004). For the moment, there is not one economic subject whose core activity is the provision of high-quality, updated and precise information in the field of traffic.

The information contents providers appear also as users of another provider, i.e. they are users of some information services which results in the question of the quality of the input data which they further use and publish. The problem increases with the taking over of information from unverified source and through further distribution to the interested users at the expense of quality and up-to-datedness of taking over and distributing. This very often results in the publication of information that are modified or fail to be of value any more.

- Personal users

Personal users of the traffic system services can be drivers of passenger cars, passengers in public transport means and persons with special needs (the disabled, handicapped and senior persons) who will use STTIM in order to increase their mobility in realizing their private, business or tourist interests. In order to raise the satisfaction level of the users, it is necessary to create services of pre- and on-travel information.

Taking into consideration the fact that the Republic of Croatia is at the moment one of the most desirable tourist destinations, a traffic system should be built that will be able to serve daily the passengers and transport of goods, as well as to increasingly interested tourists especially since they have already learned in their home countries or countries they had visited how to use certain classes of services.

- Public transport operators

Public transport operators can appear as users in all traffic system modes as air operators, rail operators, companies of public urban and suburban traffic, companies for intercity international road line and free transport of passengers and taxi services, VIP taxi at hotels i.e. companies that operate public transport in passenger traffic and that will use STTIM to improve the efficiency of operation and for information of their users (passengers). Moreover, they can serve as source of information (e.g. about the incidents which involve their transport means or as witnesses of a certain incident) to systems for information management regarding the traffic condition.

- Operators of commercial transport means

Operators of commercial transport means (so-called cargo transport agencies) in any transport mode are air operators, rail traffic operators, companies for intercity and international road transport of goods and logistics, companies for road transport of special cargo, postal services and companies that perform courier and package deliveries on a wide area and companies that perform package deliveries within the city area, i.e. companies that transport commercial goods, packages, business documentation, etc. and can use single ITS services to improve the efficiency of their operation in the city, intercity and international traffic. As in Item 4 (Public transport operators), all of them can serve as source of information, e.g. about the incidents which involve their transport means or they can act as witnesses of an incident.

- Public security activities

The public security activities mean those activities that would benefit from ITS by providing better services as for instance the army, police, firefighting units, emergency medical services, towing services, property insurance companies and companies providing safe transport of persons, money and securities. These are then organizations and companies that manage the fleet of emergency vehicles and that will use ITS to improve their operation. By analogy from the previous items and by recognizing the fundamental activities e.g. of police or Services for emergency medical interventions, it is obvious that they are also a good source of information on the traffic condition.

- Companies managing a fleet of vehicles for their core activities

There are numerous companies in the Republic of Croatia that have the need to use their own, big fleets of vehicles to perform their core activities, such as the companies for the delivery of their products, or ambulatory sales, companies for communal activities and companies that are engaged in maintenance and construction of road infrastructure, electrical and gas networks. They can expect higher efficiency with ITS technology application in their operation, and each of them can of its own accord join the dissertation model and become the source of information.

- Telecom operators

These are the companies that provide access to the telecommunication networks for all forms of transmitting sound and data in order to enable communication among ITS elements and the service users.

Telecom operators can participate also in the distribution of information during programs by broadcasting the news or by means of RDS system thus contributing to the level of information of the drivers by means of the so-called RDS-TMC channel (Radio Data System - Traffic Message Channel)[2] via FM radio-diffusion, for the users who have the user's device (radio receiver) that supports RDS reception.

- Independent companies

This group of users includes the companies that manufacture or maintain and improve the transport means, follow the ITS development, deal with installations, sales and maintenance of ITS equipment.

The model presented in the work assumes that all the potential ITS service users in the Republic of Croatia can also be the source of information for STTIM operation.

The generalized model of traffic data manipulation on the basis of which the STTIM operation model has been developed is presented in Figure 10.

The model understands assigning of different weight values to the information from single sources. For instance, any driver of the transport means, traffic system participant or even a accidental passer-by can report an incident situation. However, such information certainly has to be verified. If a known driver is involved (or a user of this service), the information may be assigned a higher weight value. If for instance an ambulance (for emergency medical assistance) or taxi vehicle are involved in the event there is small probability that the received information needs to be verified, i.e. that it fails to correspond to the actual situation in the traffic system. If the police wants to inform other users about the incident event on the roads, we can state with certainty that it is precise, updated and verified information of the highest weight value.

[2] For more detailed cf. official Internet server of TPEG project at the address http://www.tisa.org/

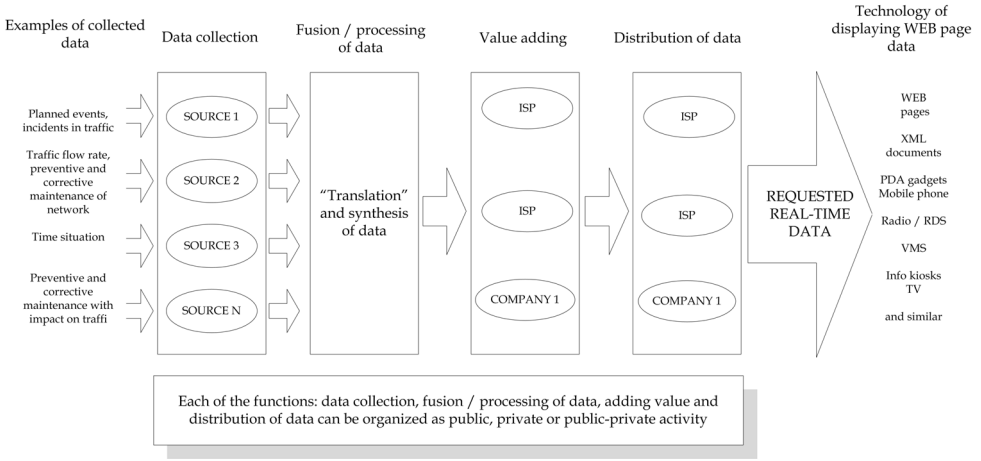

Fig. 10. Generalized model of collecting and processing of traffic data

The same analogy can be used also for the event in the category of preventive and corrective maintenance of network infrastructure and other similar events that may generate influence on the traffic flow. For the sake of example, if in the city of Zagreb the Zrinjevac Ltd. Company, whose core activity is to take care of the green areas, publishes the information in the city about the mowing of the grass areas along the road, the authenticity of this information need not be checked. If the information is not published, every conscientious citizen can report the event in which the intensity of the impact of events on the traffic flow is described, but then such information should be assessed and it should be assigned a certain weight value.

Figure 11 shows a generalized presentation of information and communication connection of the traffic system users included in the processes of *production* of real-time information on the traffic system condition.

The area of research encompasses the problematic of the fusion and processing of data on a generalized level, and the emphasis is oriented to the identification of the source, technology of collecting and distributing information to the interested parties. It should also be mentioned that it is precisely the problems of fusion and processing that are extremely important in this process. Numerous further studies will have to be oriented to this area, so that the users would receive high-quality timely information.

It should be emphasised that each function in the work of the generalized model can be organized as public, private or public-private activity.

Recommendations for the development of legal standards and definition of business models in which also the private sector may participate in the development of telematic-based systems of real-time information of all those interested in traffic condition (*Traffic and Travel Information* – TTI) were given by the European Commission on 4 July 2001, No. 201/551/EC (European Commission, 2001).

The business model for traffic information management has been analyzed in several research works and can appear in various forms (US Department of Transportation, 2004). The model which stands out with its advantages, and is applicable in the Republic of Croatia is the public-oriented business model presented in Figure 12.

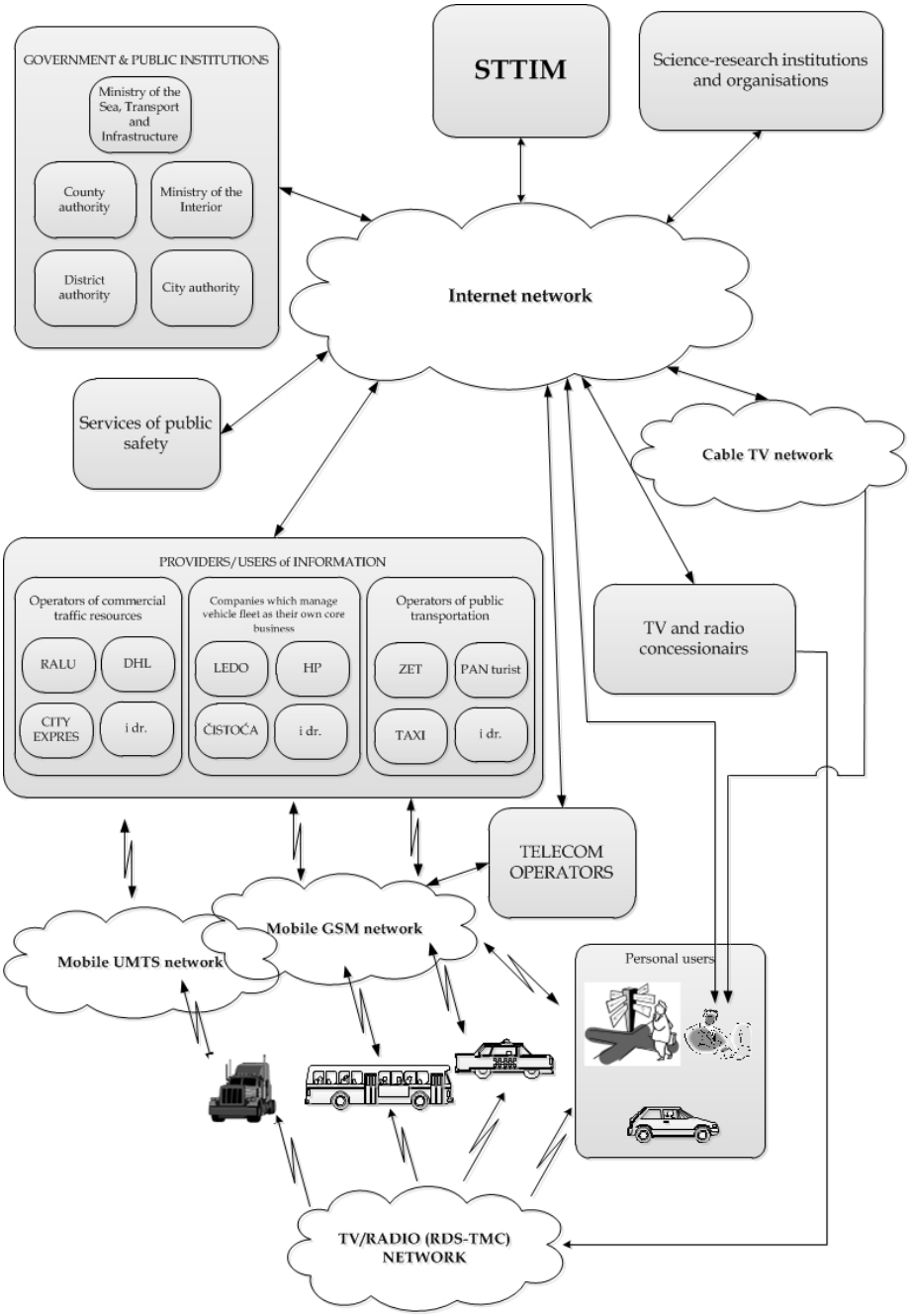

Fig. 11. Generalized presentation of information and communication connections of traffic system users

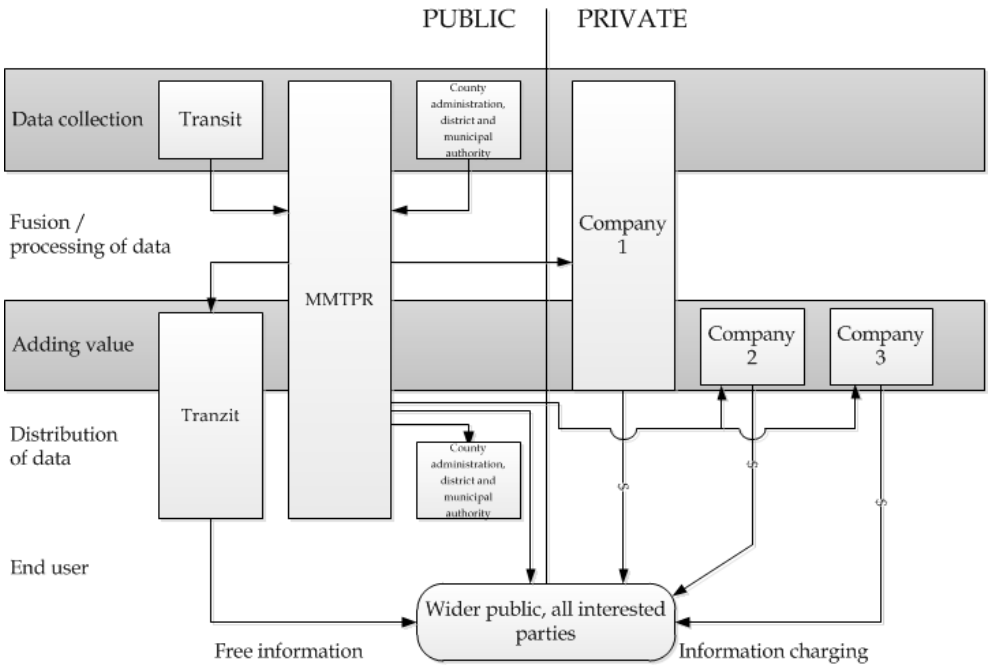

Fig. 12. Public-oriented business generalized model of traffic data manipulation

4. UML Model with notation

In this section the model, which is the result of the research using UML notation, is presented.

4.1 Presentation of the model by diagram of usage case

In the generalized presentation Figure 13 shows different groups of users who use the services of the traffic information management system (STTIM). The basic categories of services include reporting of individual events depending on the authorities and requests on the condition in the traffic system which are distributed with or without charge. The synchronization and harmonization of work of all the programme package modules are preformed by the application called STUP (Cro. Stanje u prometu – Condition in traffic) (Peraković, 2006). The protection of data during input, processing and distribution for the services of special purposes such as police, army, etc. has also been planned.

4.2 Presentation of the modular structure of STUP application

Figure 14 gives a presentation and the logic model of the operation of the developed software package called STUP AP (Peraković, 2006). Eight synchronized applications follow the input, processing and distribution of information of the known and unknown users and users with special requests regarding data security.

The basis of the STUP operation is the database into which every input of a new event and every new request for a service is entered.

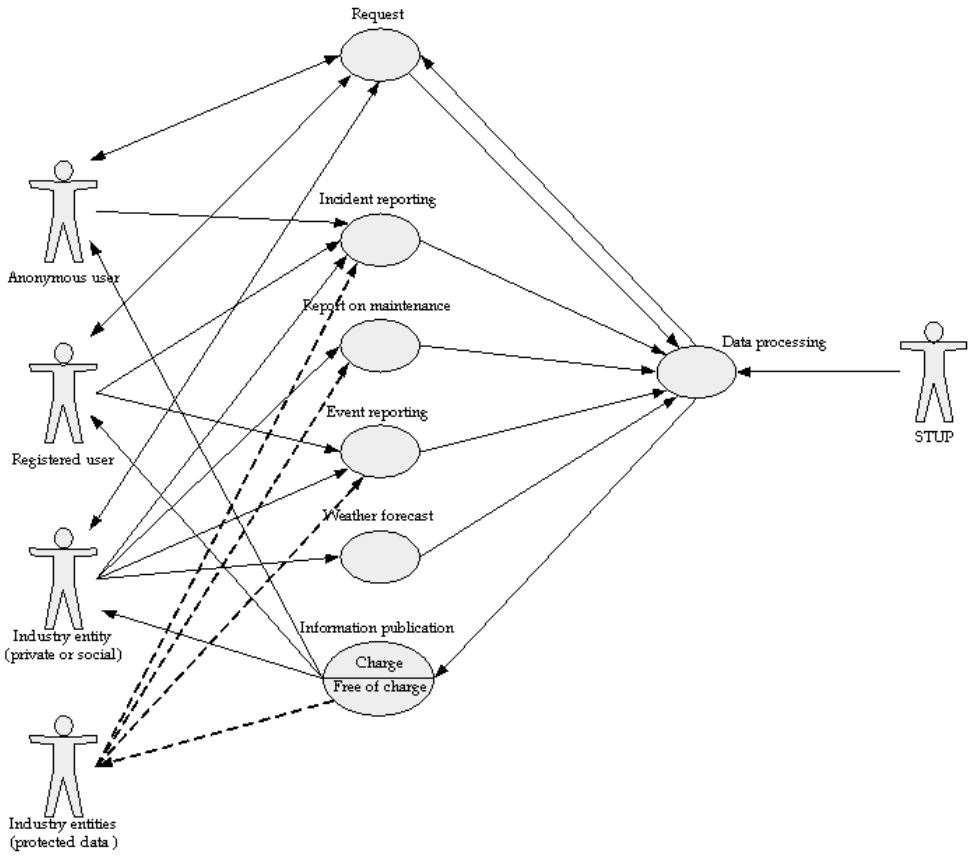

Fig. 13. Model presentation by UML diagram application of case of usage

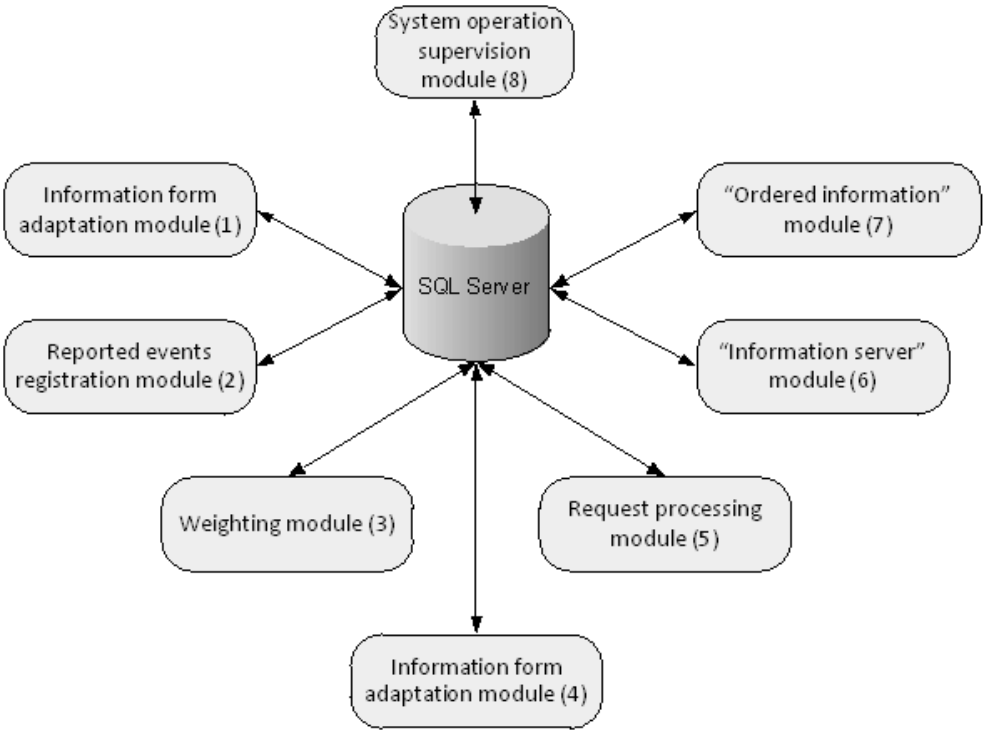

Fig. 14. Modular structure of STUP application

5. Conclusion

The work presents the results of several years of research of the very actual problematics regarding information of traffic system participants with emphasis on the possibility of applying advanced information and communication systems and services with the aim of providing reliable, precise and timely information necessary for harmonized operation and sustainable development of the transport system.

The traffic condition information is the base for creating the ITS service classes such as pre-travel information for travel planning and on travel information, information about public transport, traffic information for motorists during driving about road conditions, services of mobile charging, tourist information, etc.

A presentation is given regarding identified and classified potential sources of information, as well as of the traffic system users and the potential new users of ITS information services.

As the biggest network of computer networks, the Internet is the most suitable infrastructure which provides the possibility to realize access to ITS information subsystems. The factors of success and spreading of the Internet lie in its exploitation properties, flexibility and ease of implementation and application, and simple and relatively financially inexpensive access with the application of the today easily accessible terminal equipment.

With the development of mobile communication systems and the provision of new services, the Internet users can be both the motorists and the passengers, i.e. users on the move, and not just stationary persons. The advanced mobile communication systems provide services that make it possible to realize the real-time information of mobile users of the traffic system, with the possibility of realizing the financial benefits in the STTIM operation.

The work proposes and describes one of the possible business models of forming and operation of STTIM (public-oriented business model). Further research need to be oriented to research of the possibility of implementing others as well, such as: business model based on the franchise contract and market-oriented business model of traffic data manipulation.

As the transport system of today is unimaginable without information and managing systems that represent the backbone of traffic security and transport, IT risk management plays an important role in the development and management of all transportation systems. Identification of security risks is a process that allows quality and more cost-effective decision-making regarding the promotion and improvement of security.

Global business process automation, and mass introduction of information technologies in business companies from the transport environment, sets major challenge to quality management of IT systems which are dependent on the business processes.

By the advent of new services in the communication systems, based on the XaaS principles, the management problematic and end distribution and (optional) charging traffic information gain a new dimension and require continuation of research in this direction.

XaaS is a very suitable platform, both for private companies and corporations, and for the government. The advantages such as reliability, conditional security, high availability, low maintenance level (depending on the model) and scalability, are extremely interesting characteristics of XaaS platforms. However, attention should be paid to the problems of security and privacy of data and to the SLA agreement conditions. Regarding the delicate nature of data handled by ITS, additional efforts should be invested in defining the Service Layer Agreement (SLA), End User Licence Agreement (EULA) and Terms of Service (TOS) with special reference to data security and privacy. This method of negotiating services (by defining SLA, EULA and TOS) can only be observed by telecom operators so that in this case they are ideal partner for the provision of STTIM XaaS platform

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