Selected Aspects of Message Transmission Management in ITS Systems

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Abstract. This paper discusses selected aspects of data exchange in ITS systems. Characteristics of data sources and recipients in ITS systems have been determined. An example showing the scale of data exchange within a given telematic subsystem has been presented. Factors causing data feed latency have been identified. Key aspects of information flow management have been recognised.

Keywords: telematics-enabled devices, ITS systems, data transmission.

1 Introduction

We are now right in a historically important pivotal point for the development of transport systems. In this tipping point the telecommunication and IT technologies meet to take over the helm and decide about the future shape of transport services. The modern transport services market has become flexible and independent of rigid delivery schedules or timetables. This applies to what, how and in what quantities to transport. All those measures are deployed to minimise outlays incurred through the transportation process. At the same time teleinformatic resources were recognised as paramount to support transport. Consequently they also improve the traffic safety, the traffic management coordination and the information about travellers. Hence, ITS systems are to the benefit of all parties involved.

The common denominator for all those measures are research and implementation programmes concerning ITS. Those initiatives, first started in the seventies [9] in Japan, USA, Australia and later on in Europe, paved the way for developing many telematics devices, today commonplace in vehicles (e.g.: GPS, proximity sensors), in the streets (e.g. variable-message sign, weather stations), on public transport stops (e.g.: notice displays, request stop buttons), in parking lots (car park spaces display, parking guidance system, number plate recognition system) and in many other places [8, 10, 11, 13].

In terms of ITS development Poland is in a very good place at the moment. For several years, current thoroughfares have undergone modernisation and new ones have been built. What is more, Poland is not burdened with obsolete, non-depreciated telematic equipment. Because of negligence many former, imperfect systems had not

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been implemented in the first place. Hence, while building new roads or modernising the existing ones, state-of-the-art telematic solutions will find their place in the infrastructure consequently putting Poland firmly on the map in terms of countries using ITS. Substantial implementation costs call for a correct planning underpinning those projects. It is a common knowledge that ITS-related investment outlays incurred whilst building or modernising roads are a fraction of possible retrofit costs.

A considerable responsibility for developing new telematic systems rests on shoulders of transport research institutions. Their key objectives include:

- Projecting the demand and developing new telematic services,
- Case studies and devising assumptions for system,
- Developing new technical solutions and employing the existing ones for purposes of new telematic systems,
- Assuring ergonomic solutions,
- Impact analysis of telematic systems in terms of their influence on safety,
- Assessing the impact of implementing new systems.

Among some of issues currently under research, the problem of interoperability of telematic systems and their components came to the fore. This is particularly important in the context of peer data exchange between systems delivered by different developers. According to ITS America [3] the following are key:

- safety of vehicle to vehicle communications (V2V),
- safety of vehicle to infrastructure communications (V2I),
- real-time data acquisition,
- developing applications for a dynamic mobility,
- better access to weather and environmental information.

At present, Poland has to focus on implementing new ITS-enabled systems and on integrating them to assure a seamless data exchange.

In the remainder of this paper, some aspects of data exchange will be listed and elaborated on, in the context of exchanging telematics-based information within ITS systems.

2 State of the Art in the Data Exchange within the ITS

According to [3], the ITS aims to improve the transport safety and mobility and to optimise its efficiency through the integration of advanced telecommunication technologies for purposes of transport infrastructure and vehicle solutions. Hence, the ITS comprises a wide range of wireless and wire resources based on IT and electronics, as well as measures aiming to manage – based on the acquired and projected information – ITS-enabled facilities/sites.

Absolutely key for those systems is the end-to-end full and reliable information. It can be generated by both vehicles and transport infrastructure, and it is the first link in the dataflow chain. Majority of that information is concise and over-abundant in volume. Examples are satellite navigation, road surface sensor (roadway weather information), inductive loops embedded in road lanes, etc. [11].

The information generated by the infrastructure and vehicles has to be correctly disseminated. Converged wireless networks are the centrepiece in this process. From the technical point of view there are wide-area and local-area networks. Currently local-area wireless networks are in intensive development as far as V2V and V2I communications are concerned.

Once the information reaches its recipient it is processed. The information processing is one of the highest priority and urgent tasks in hand of standardisation offices. As the technical solutions are not integrated, there are no developed data exchange protocols and solutions delivered by different software houses are numerous. This state of affairs constrains the interoperation between telematic systems located within a given area. This violates the very idea of ITS and diminishes its impact on transport processes [12].

Should the aforementioned issues of information processing be ignored and it was perceived as unambiguous, it then comes as "mine of knowledge" for the traffic decision support & demand management systems. In the author's opinion, only then ITS objectives could be met.

The information flow is represented holistically, i.e. including available technologies and utilitarian factors in Fig. 1.

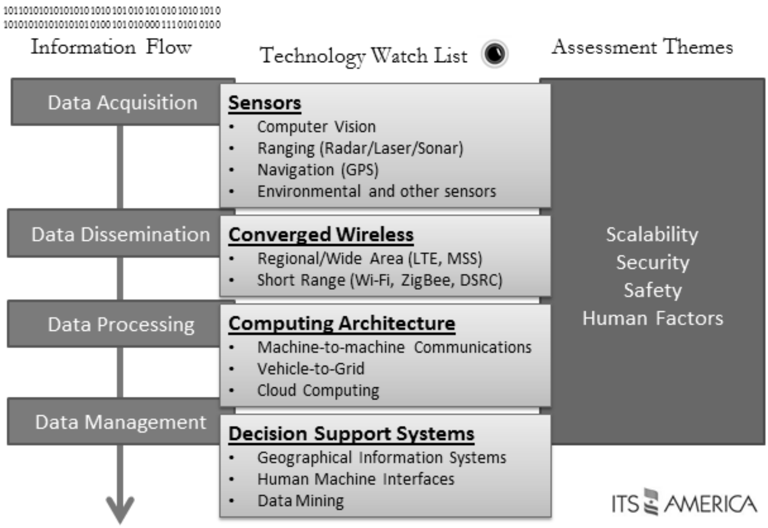

Fig. 1. Information flow in ITS systems. Source: [3].

2.1 Sources of Information in ITS systems

Vehicles are the greatest group of information sources and recipients in ITS systems. Telematics-enabled, independently of the driver, they can feed the location coordinates, the vehicle maintenance data and the transported cargo information to a logistic base. The information acquired by vehicle sensors can also serve purposefully to other drivers within the closest proximity to the vehicle. V2V communications could find its use here, to feed the data about the current speed or to make an e-call.

Another group of information sources comprises road infrastructure sensors. The data from those sensors can be transmitted in a twofold manner. On the one hand, normally over wires, the information is fed to management centres, on the other hand, over wireless and via access points it is fed to vehicles driving past the sensor. Infrastructural sensors can be used in a multifaceted manner. The most popular applications are the assessment of lane occupancy and of traffic volume. Apart from these two, important are roadway weather information systems and air quality sensors feeding the information about hazards created by e.g. road surface conditions. They are normally complex systems transmitting a processed information about road surface conditions based on many sensors and processing algorithms. Another popular use of ITS includes electronic toll collection on toll roads. An interesting, yet not the only, application for infrastructural sensors is predicting the congestion and rapidly changing road hazards. Intelligent IP cameras are best-suited for this role, whose built-in video filters can generate warning and emergency signals.

Another crucial source of information are satellite positioning systems. At this point in time, there are four major systems. American GPS, Russian GLONASS, European GALILEO and Chinese COMPASS [5, 7]. The American GPS is the most popular solution. It uses the NMEA-0183 protocol (*National Marine Electronics Association*) capable of sending data at 4800 baud.

2.2 Data Feed to End-Consumers

The acquired and processed telematics-based information is transmitted via various communication interfaces [1, 6]. That information is displayed in vehicles, by variable-message signs along roads, on public transport stops and at travel information centres [10, 13].

The information displayed to drivers should influence their decisions concerning driving itself and choosing optimum routes. Generally speaking, that information should enhance the driving comfort as well as improve safety. The data is fed to the driver over Man to Machine (M2M) interfaces, which might include video displays of built-in touch screens, head-up displays, IVR voice communication and voice recognition systems, and other more conventional features. Nowadays the development of those systems is dictated by stringent requirements for the driver safety. Telematic driver assistance systems can automatically reduce the speed upon joining the vehicle in front or even brake before a barrier. On the other hand, studies carried out for purposes of aviation in the seventies, and later for ITS, proved that an incorrect data fed to the driver causes distraction and absent-mindedness, which in turn could potentially cause an accident.

Variable-message signs are a bright indication of ITS at work. They are a replacement for traditional notice boards. Drivers obtain numerous pieces of information helpful in driving a vehicle. What is an important feature, those solutions operate in real-time, i.e. change the displayed information depending on the current weather conditions and traffic situation. Variable-message signs also influence the traffic in areas where so far they have not been used. Examples include car parks and urban agglomeration welcome signs.

3 Information Analysis in Telematic Systems

The task of analysing comprehensively the information volumes involved in ITS systems is a complex one, depending on numerous technical factors, but above all on time-constraints imposed by the dynamics of those systems. Hence the data transmission could be classified as continuous and discrete (discontinuous). A continuous transmission is normally associated with media streaming, whilst a discrete transmission is more popular and associated with the current status reporting and controlling equipment.

3.1 Data Volume

The issue will be illustrated with an example of an abstract ITS system supporting a tram operator. As far as the issue of positioning vehicles is solely concerned, assuming the ITS-enabled area to be the agglomeration of Warsaw whose current rail infrastructure is 276.5 km long, current (February 2012) number of carriages is 837 and each carriage will feed its position in 3 second intervals, the number of messages either accumulated on-board or fed to the surveillance centre could reach 1200 per hour. In the entire enterprise (the entire rolling stock) that number soars to 1004400 messages. Thus, over 24 hours this translates to tremendous 24 million messages, which have to be transmitted, accumulated and processed let alone for documenting purposes, to prove the meeting of contractual obligations to deliver timely the transportation services.

There are two things to note here. Firstly the update time for carriage positioning. The three second interval seems small, however, since vehicles travel at 40 km/h on average, between consecutive readings the carriage covers 33 metres. This is not a satisfactory enough metric from the standpoint of vehicle position over time. Secondly, and more importantly, this is one of several sources of information. Apart from positioning information, telematic devices can generate information about vehicle parameters, number of seats taken, security etc. This means, the amount of information would have been substantially greater than the above-mentioned.

3.2 Data Latency

The phenomenon of latency is commonly associated with a network delay. This is an inaccurate statement narrowing down the issue to information transmission only. Nevertheless, message latencies depend on multiple factors which include:

- delays generated by the equipment,
- packetisation time depending on the frame size used by the protocol,

- transmission delay of individual connections,
- node waiting time,
- node buffering time to compensate for jitter,
- target node buffering time,
- target node processing time (information management centre),
- response time.

All the above-mentioned factors are characteristic of package networks. In the case of using circuit-switching networks, a substantial part of delay-generating activities would have been eliminated. Unfortunately the circuit-switching networks are the least efficient and therefore it has to be assumed that packet-switching networks would have been used. One of arguments in favour of this solution is the ubiquity of internet which is based on IP packet-switching protocol.

3.3 Data Management in the System

The information management can be carried out in either central or distributed manner. The solution selection depends on the size of and on constraints on the message processing time. The literature gives comprehensive information about advantages and disadvantages of every data management method. The examples illustrated in paragraph 3.1 reveal the scale of the problem – the provided central model is adopted. The decentralisation augurs well for simplifying the management process, however it fails to give a broad, global overview of the system.

Regardless of the method selected for the ITS system, the transmitted information has to be methodised in terms of:

- weight/priority of message,
- access privileges/publicity of message,
- message demand,
- message-based inference,
- predicting subsequent messages based on the previously received ones (in case of message loss),
- others.

4 Conclusion

Issues discussed in this paper are only part of broader deliberations over data exchange within ITS systems. Should organisations such ISO or ITU-T introduce unified standards, it would give more consistency. The lack of such standards, on the other hand, leads to the discretion in developing telematics-enabled equipment. Consequently the rolled-out solutions are incompatible and time constraints are imposed on the data exchange.

Research institutes have to answer the following questions:

- How to build the data exchange and management systems?
- To what extent should the ITS communication systems be open?
- How to assure security of the ITS telecommunication systems?
- Is the information fed by the system reliable?
- How to define and assess reliability of communication system in ITS?
- To what extent is the ITS-fed information distracting for the driver?

Furthermore, both developers and their clients should consider when designing and implementing ITS systems:

- How many messages are received?
- What size are those messages?
- What resources are used to transmit those messages?
- In what order should they be processed and transmitted?
- What data-centric systems will process gathered information?
- What criteria should be adopted when deciding about the distribution of processed information?

It is fair to say, that once those questions will have been answered over the forthcoming years, the integration and management of ITS will have become easier.

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