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Analysis of elements of telematic systems interaction and rules of their mutual communication

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ABSTRACT
The paper presents an analysis of the basic principles of telematic systems in which the timely execution of tasks and the interaction of those systems distributed modules is the critical element. The first part lists the most important ideas and concepts of real-time systems. The second part refers to the communication principles of elements of a distributed telematic system-level exchange of messages of the third layer of the OSI model. The last part presents an example of a telematic system in terms of reported issues

KEYWORDS: telematic systems, real-time systems, communication

1. Introduction

The information society development and constantly increasing volume of road transport resulted in a significant increase in the number of services offered by ITS systems. A general division of these services has been described by several standards organizations of which TC 204 is the most important. The ISO 14813 has characterized eleven areas of ITS services which include: Traveler Information, Traffic Management, Services, Vehicles, Freight Transportation, Public Transportation, Emergency, Transportation-Related Electronic Payment, Road Transport-Related Personal Safety, Weather and Environmental Conditions Monitoring, Disaster Response Management and Coordination, National Security. Each of these areas requires the use of specific services or of prepared telematic devices, where the interaction within the system will ensure achievement of objectives.

Most telematic systems should be classified as real-time systems, which operate on the principle of severe time limitations. Another feature of these systems is their distributed structure, whose elements (sensors /actuators) are located at various places such as vehicles, road shoulders and the public transport. Examples of such systems were presented by the RITA (Research and Technology Innovate Administration) and are available on the website (http://www.itsoverview.its.dot.gov/). About fifty different systems of supporting the implementation of ITS services are mentioned there. Each of these systems, based on a network of sensors collecting and disseminating a variety of information processed by a dedicated driver or the Traffic Management Centers, is designed to improve the road transport.

That character of telematic systems leads to fundamental questions about the methods of communication between devices within the system and the rules of the information exchange at the level of systems management. The mentioned source (RITA) considers in general terms both methods of communication between the systems and the scope of messages.

2. Character of Telematic Devices Operation

Telematic systems are a group of systems responding to events (Event-Driven System), that is their behavior depends on external events occurring in their environment. For such systems there is a direct action (Straight Forward), which describes the immediate reaction or a reaction in a determined the time (Due-Time). That time is strictly defined due to the continuity of transport processes and to response capacities of the recipients of information from telematic devices over time. If a message is delivered over a period longer than expected (Deadline), such message is defined as expired and preventive measures undertaken. It is possible to talk about systems in which the timeout can be treated as a system failure (Hard Deadline) or a distortion of its operation (Soft Deadline). Examples of the first category of systems include vehicle operation support systems, electronic toll collection systems, and systems of national security. Telematic systems, which exceeded response time does not lead to safety risks, may include travel information systems, management systems of public transport and systems of data archiving.

The presented time conditions are characteristic of real-time systems, which are widely described in handbooks on the theory of industrial automation and computer techniques. The use of these sources may be helpful to solve many problems related with the operation of telematic systems. One of them is scalability, which means that the size of the system, expressed by the number of attached thereto components (devices), can be customized to the customer requirements, but also to further development. Scalable real-time systems lead to a number of issues related to the concurrence of their activities and mutual synchronization of tasks and processes, also to access to limited resources and communication among devices.

The concurrence is defined as a process based on the coexistence of multiple processes carried out simultaneously and assuming data sharing. While in the case of a system in which each of components has an internal processor and memory it is possible to talk about the system hardware concurrence, whereas in the case of systems with a central management unit it is possible to talk about pseudo-concurrence performed actions. In practice, the number of tasks to be performed always exceeds the number of processors in the module, so a full concurrence of hardware may be referred to only for structures of FPGA (Field Programmable Gate Array). The concept of concurrence in telematic systems is bound by a common struggle of resources in the system. This problem is very important, because large distributed telematic systems usually refer to the global database by reading the current states for example of the traffic, busy parking area, pavement condition in different parts of the road, etc. Simultaneous access to records of the database by a number of control modules is just an example of such sharing of a limited resource. The lack of access control mechanisms leads to overwriting the data of the processes carried out at the same time based on past data sets. To this end telematic systems should take into account the problem of mutual exclusion tasks, which brings the need to guarantee the execution of disjoint fragments of tasks in which a reference is made to the common system resources. These fragments are called critical regions or short regions.

The experience of telecommunications engineers and computer scientists, the execution of two or more tasks at the same time requires the introduction of mechanisms for their synchronization. The task synchronization occurs during the execution of a greater number of concurrent tasks, each of which is carried out independently, but with the moments at which each will have to replace the information, or to communicate. It should be noted that in the discussed systems, the sequence of operations depends largely on the sequence and timing of external events initiating the processes in the system, so it is not possible to predict. This lack of determinism in the process of calculation cannot mean a lack of control and security of processes. The achieving of tasks synchronization is possible through appropriate control processes and mechanisms of resting the responsibility on both the programmer's choice of programming language and operating system. The most popular mechanisms used include the application of a buffer and instructions suspend "Suspend" and resume "Resume". A more advanced technique consists in using a structure known as the semaphore. It is a system variable whose value can be checked and changed by all the tasks using manual Wait (S) and Signal (S).

A major problem related to the synchronization of tasks is the possibility of deadlock group of tasks, namely a situation where the suspended task is waiting for the resumption of the task, which in turn is suspended pending the resumption of the former. The deadlock may result from the existence of the state that has no output transition or an output transition is based on the event which will never happen. The mechanism of critical decision is a method of defending against deadlock. It is based on the attribution of priorities or tasks using the meeting time (Timed Rendezvous). But the easiest way is to block all other tasks before the task releases the occupied resources.

Issues described above are not new but authors noted that they are not known or trivialized by developers of the road transport telematic systems.

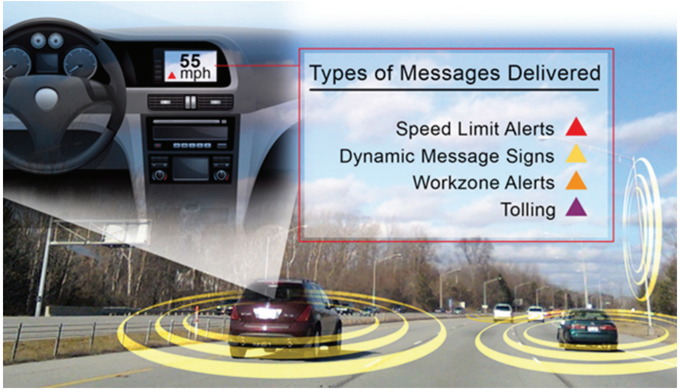

Fig 1. Wireless communications between Vehicles and Infrastructure (V2I).
Source: http://www.its.dot.gov/press/its_images.htm

3. Analysis of Communication Messages in Telematic Systems

Modern communications provide several means of information transmission both inside the telematic systems, as well as outside. They are divided into wired and radio, the first of which contrary to popular belief are a major percentage of all solutions. The popularity of wired communications results from a higher reliability of links, and a high resistance to interference and much higher level of security of the information transmitted. However, the use of wireless communication is needed in cases of transmitting messages, such as warning messages, from and to vehicles during their trips. That is when cars are approaching a traffic signal, the wireless communication allows cars to be aware of all other vehicles on the road, even if the drivers are not. The wireless connectivity allows cars to be continuously aware of each other, where they are, so if a car suddenly brakes the cars several yards behind the vehicle get a safety warning before they get too close. Another typical case is a contactless identification of vehicles at characteristic points, e.g. at places charging fees for entering the highway. In wireless communication telematic devices an increasing attention is paid to the wireless vehicle to vehicle communication (V2V communication). Examples of V2V communication on freeways will help to prevent crashes, Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) communication showing types of messages V2I that can be delivered to the vehicle.

The variety of available means and methods of communication leads to fundamental problems, related to adjusting the message form and content to the possibility of teletransmission through wired and wireless networks. The basic reference is the model of layered networks OSI (Open System Interconnection), developed by ISO (ISO standard 7498-1). The model is a reference for most of today telecommunication standards. It defines seven layers organized in such a way that each of them provides services to the adjacent layers. Among the layers, the three upper layers (L7 – Application Layer, L6 – Presentation Layer and L6 – Session Layer) are directly implemented in the software controlling the system modules while the lower layers take an active part in preparation of data for transmission. The Transport Layer (L4) segments are long or consist of sets of data. The Network Layer (L3) is responsible for switching the data streams. The Data Link Layer (L2) is responsible for ensuring a transparent channel (error-free) communication and describes the characteristics of the Physical Layer (L1) interfaces and contacts between devices and systems.

The analysis of the principles of communication at the first and second layers is different for each of the adopted transmission media and technology of communication. Similar situation is in layers from the fifth to the seventh, where the information is processed to the specific needs of IO interfaces. As a result the analysis and any action to integrate devices and telematic systems need to focus on OSI layer three and four.

The adaptation of telematic devices at the transport layer involves the establishment of common rules to control the reliability of a given link through flow control, segmentation/desegmentation of large data portions and to allow the error control. The network layer is responsible for the process of establishing, maintaining and terminating the exchange of messages. In connectionless networks it is responsible for the proper routing of data packets. The network layer during the process of compiling a call negotiates the terms of communicating parties.

4. Analysis of the Information Exchange on the Example of Network Design for IP Management and Control of Traffic on a Highway

An example of analysis of information sharing in telematic systems can be an IP communications network project for the management and control of traffic on a highway, where the main aim is to provide the network communication capabilities of various systems that make up the whole system, while maintaining adequate security. Main communication network nodes (switches and routers) are placed in functional buildings (SPO, PPO, OUA)

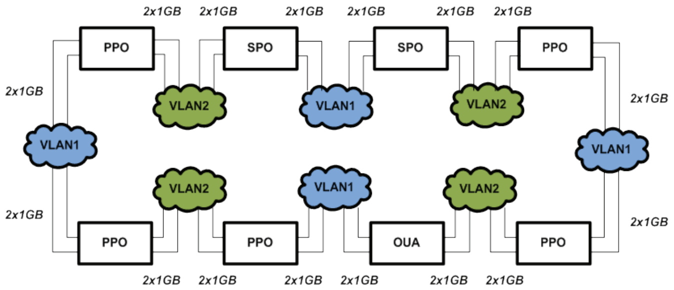

Fig 2. Backbone topology connections between locations.
Source: own study

in all locations on the motorway junctions. The analyzed network consists of two functional parts: backbone, providing connectivity between locations (SPO, PPO, OUA) and the local area in a single location.

The backbone network is built based on the Ethernet switches which, in each location, operate modular hardware redundancy. Ethernet switches are connected in a ring topology using optical ports. In order to increase the bandwidth between locations for redundancy and devices used in the modular version aggregation on the physical level. The backbone network packets are routed between locations, using the functionality of Ethernet routing switches. The transfer of traffic organization on the third layer of the OSI model (network) provides a separation between the locations of the second layer of the OSI model, for protocols such as ARP (Address Resolution Protocol), which improves the network performance and prevents the transmission of traffic generated by the disturbance of applications in one subnet to the other virtual network.

Figure 2 shows a diagram of the backbone network at the physical layer. Two 1GB links working in LAG (Link Aggregation Group) will be used for communication between different locations, increasing the available bandwidth, double the rate 2GB. These links belong to different VLANs as shown in Figure 2.

A local loop provides a transport-access layer, the second model in OSI implemented for all systems on the network backbone. The loop is constructed in a ring topology with Turbo Ring protection, as shown in Figure 3.

Local loop-access is connected with two calls from two different devices. The Turbo Ring protocol used in the network topology protects against the loss of resources of the ring in case of damage to the network. This protocol, when connection is broken in the ring, reconfigures the network and communication switches to a redundant path in time, which is always less than 300ms. Switches connected in this architecture, blocking one of the calls, thus prevent the occurrence of loops in an Ethernet network. In the event of any interruption of the connection, the switches will automatically detect this event and reconfigure the network to a redundant (backup) path. The restoration of communications networks for 10/100 connection is always in less than 300ms. Ports, which are connected to the local loop-access to the core network, are configured as transit packets moving between different systems to ensure separation between the VLANs.

In the backbone network used in the field of network management and divided in such a way that the addressing plan concerns the connections between locations in the aggregation network. The VLANs in a network backbone running OSPF dynamic routing protocol is responsible for filling the dynamic routing tables of switches. Telematic devices, such as highway motorway meteorological stations, controllers and variable message signs, are

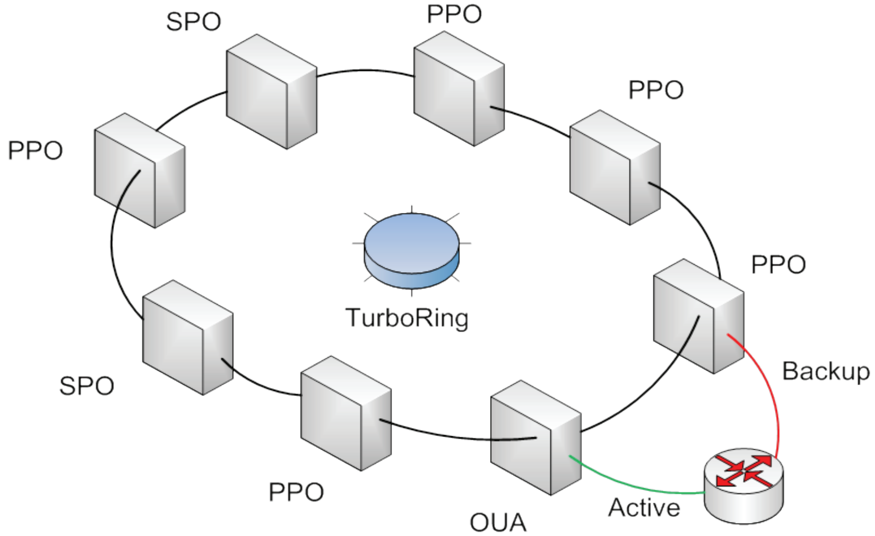

Fig 3. Connecting local loop access to the network backbone.
Source: own study

connected to the local access network using switches and through the virtual network VLAN created for the needs of remote management and monitoring to assure the safety switches and control over network traffic.

5. Conclusion

The paper presents an analysis of the basic principles of telematic systems operation, particularly systems in which the timely execution of tasks and the interaction of distributed modules of these systems is the critical element. The presented concepts and issues of real-time systems are not new, but the authors noted that they are not known or underestimated by the people developing road transport telematic systems. An example of network design for IP management and control of traffic on the highway shows the character of telematic systems and related temporary conditions.

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