ISSN: 1231-4005
e-ISSN: 2354-0133
DOI: 10.5604/01.3001.0012.4361

LoRaWAN NETWORKS IN AUTOMOTIVE APPLICATIONS

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Abstract

Development of IoT is tightly coupled with the use of the wireless communication solutions. Nowadays there are several standard wireless protocols, which are responsible for carrying information. The increase of the communication traffic tends to specialize the kind of used data interchange methods for the sake of demanded size of data packet, frequency of connections, meaning of the data, security and safety of the transmission as well as many others. One of the intensively spreading wireless networks is LoRaWAN. Because of its low energy consumption, long distance range, and high flexibility, it seems to be very effective solution to apply in the field of road traffic. The article presented the base features of LoRaWAN as well as the conception of virtual local traffic system based on the data yield from the board systems of cars. Accessed from OBD information about f. e.g. temporary cars speed or accelerations associated with their current position can be significant factor in creating the real image of the traffic situation.

Keywords: *automotive, communication networks, car parameter monitoring, CAN, modular system*

1. Introduction

Modern Automotive exists as a part of cyberspace. The diagnostic and control of car as well as their existence in the environment are based on exchange, and processing a huge data flow. The elements of such complex systems exchange the information in specific to application conditions.

Complex approach to the safe and effective functioning of the road transport assumes considering the car and the road infrastructure as one integrated structure. In this way, on-board information corresponds closely to the external environment of the vehicle. Information about activity of ABS, local start and stop frequency, temporary accelerations etc. can be used to estimate the road-traffic or state of the road surface. Building the road condition image is based on the fusion of data from many sources. There are numerous systems monitoring such parameters like average traffic intensity, local environment temperatures, or potential dangerous situations on the selected trips or regions. These systems yield data from terrestrial stationary measurement point or personal notification are sent by vehicle drivers or services responsible for the security. The significant limitation of using such systems is low density of the monitoring points and necessity of investment in physical terrain infrastructure or engaging the vehicle driver in additional activity. Information about movement parameters coming automatically from mobile objects, in some way can be treated as partially continuous in time and space position domain.

2. The communication networks in a car

In the article, the communication systems are proposed to be classified in two groups. The first group of the system focuses on the networks connecting elements in the space of body of a car. The second group are communication networks covering the data exchange between the Car and its near and far environment. The main role in the first group play standardized network protocols used to control and coordinating the subassemblies of car as well as the on board diagnostics.

These protocols are: LIN, FlexRay, MOST and CAN described widely in [5]. Nowadays the development of the on-board communication systems tends also to use in the physical and data layer Ethernet protocol, what was presented in [10, 15]. The basic protocol demanded as the mandatory interface equipment of every on board diagnostic system is CAN. Primary specification of the CAN 2.0 describes the data layer. The physical layer of CAN in automotive application is regulated by [1, 2, 6, 11, 13]. The other protocols are described in [4, 14, 16].

Because of fixed location, most of the terminals handled by these networks use the medium carrying information based on wires and plastic optical fibre (POF). In special cases, some of specialized on board systems demand wireless communication such as: tire pressure monitoring systems (TPMS) as well as user handling (driver) interfaces (usually Bluetooth).

In the second group of communication systems, the mobile nature of the car determines the use of wireless protocols connecting the car with external information space. The most typical wireless solutions used currently to exchange information between the car and external systems are f.eg. Cellular Networks or DSRC.

3. On board source of information

There are several sources of real time information about the state and events regarding current exploitation parameters of the vehicle presented in the Fig. 1. The primary basic source of data / information about the vehicle state is driver-supervisor senses and observations. However, it has the significant abilities to adapt to new situations; the information yield in this way is strongly depended on a personal experience and current constitution of the human observer.

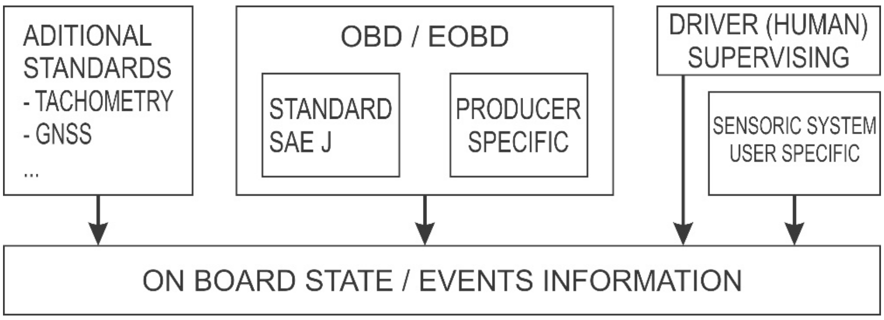

Fig. 1. The on board sources of information about the state / events of a vehicle

The compulsory in every modern car on board diagnostic system (OBD) delivers many information about the state of the car in standardized way. The base of the OBD is monitoring the state of a car in view of exhaust gasses emission and a reaction in real time to events / states defined as malfunctions. The early-assumed reactions were the remotely sending information to proper services. This way OBD represents idea of integration of car and its environment in common information space.

The OBD data acquisition is organized as the set of the so-called services accessing particular exploitation parameters [8]. The basic parameters oriented on the emission are included in (SAE J1979). Example of these can be "*$ 0x05 Request oxygen sensor monitoring test results*". Beside of services regarded directly to emission, the OBD can be source of information about the more general current exploitation parameter f.eg. "*service $ 01Request Current Powertrain Diagnostic Data*". Apart from the standardized set of services, producers include in OBD systems additional diagnostic specific information such as position of steering wheel, brake system etc. The data get from OBD can be used to reason about the car as the element of the road-traffic.

Nowadays most of cars are equipped with additional electronic devices such as GNSS receiver, or Tachometry

Systems (in trucks). Beside their specific tasks, like localization and control of driver activity, they can be redundant sources of information about the movement parameters of vehicle. As the source of information, the user specific sensors not included in standard equipment of car can be also used. The example of system able to monitor vertical acceleration of vehicle or pressures on its body surface is presented in the [12].

4. LoRaWAN

The development of IoT has direct impact on works in the field of new communication standards. The primary aim is decrease the energy consumption of communication devices as well as the increase of the transmission range and immunity against disturbances. The real effectiveness of network standard can be estimated and confirmed on the base of the number of implemented applications. One of the leader in the group of Low Power Wide Area Networks (LPWAN) is Long Range Wide-Area Networks (LoRaWAN). This protocol is laid down and described by LoRa Alliance [7].

Communication in LoRaWAN is organized as an exchange of the messages between the so-called end-devices and gates connected to Internet Network. The end-devices and gates works in the star physical topology. Exchange of data between end-nodes and gates can be realized on different frequencies and data rates .The choice of these, depends on the demanded range and duration of the message. Every end-node can work on every possible data rate. The choice of it can be controlled automatically by the Adaptive Data Rate (ADR). In case of mobile objects in changing radio environment LoRaWAN specification recommends use of the fixed default data rate.

The most significant advantage of the LoRaWAN is low energy consumption. This feature was achieved with the appliance in the physical layer Frequency Shift Keying (FSK) and specific LoRa spread spectrum modulation. Additional properties of LoRa modulation comes directly from developed in 1940's for military applications Chirp Spread Spectrum (CSS) scheme. This technique features in high resistance to such malicious phenomenon like: multipath, fading, Doppler or jamming interferences [9].

The LoRaWAN works in Europe by radio spectrum allocation ISM band defined by European Telecommunications Standards Institute (ETSI) [3]. The proprietary bands for radiated transmit output power of end-devices are: EU868MHz ISM band (14 dBm) and ETSI 433-434 MHz band (10 dBm). Data rate of LoRaWAN can be selected in scope: from 250 bps to 50 kbps. The highest value (50 kbps) is used only with the FSK modulation.

5. The concept of LoRaWAN in road traffic

Many factors should be taken into account to plan and cover a trip in the optimal ways. One of the popular supplemental source of information is the mobile application called "Yanosik". In the Yanosik, the driver formulates the message about the current road conditions and sends it to remote server. This way the application uses short messages to take part in building the road image knowledge base.

Because of the features of the LoRaWAN, the staff at the UWM works on the conception to applying it in the field of road traffic. The main idea of the system is presented in the Fig 2. It assumes the use continuously present in the on board system information to enrich building the road situation map. The proposed system connects the vehicular OBD systems with the internet cloud server through the LoRaWAN Gateways.

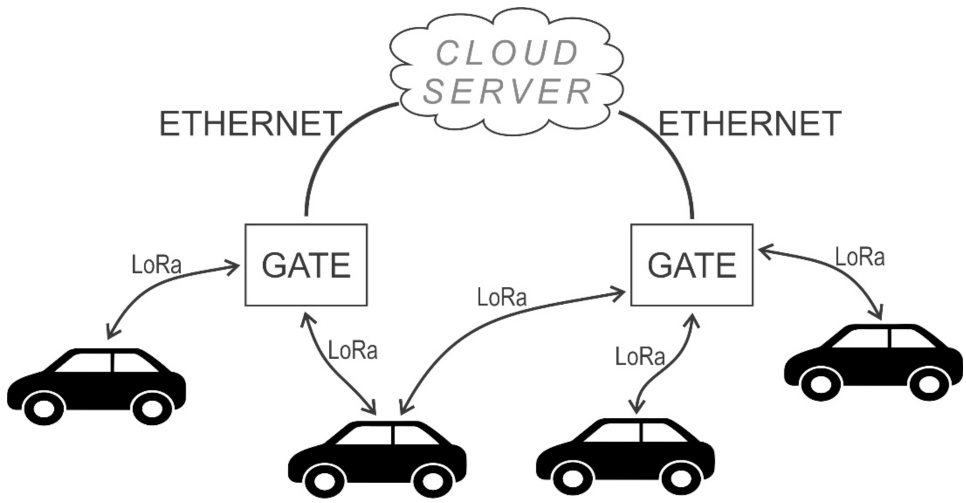

Fig. 2. Schematic of applying the LoRa in control and support Road traffic

Comparing the proposed system to systems based on increasing protocol 802.11p the LoRaWAN Solution ensures more flexibility and longer ranges. The typical Range for 802.11p is approximately 1000 m. This way, to ensure the continuous access, the terminal nodes are dedicated to be located in limited areas or along main routes. The typical LoRaWAN ranges are 5 km in urban space and 10 km or more out of them. This could allow building local LoRaWAN networks in the suburbs and rural areas where other solutions would be too expensive because of the need to build terrestrial infrastructure with significantly higher access point grid density. Important thing in organizing such LoRaWAN networks is engaging the specialized group of vehicles covering the monitored distances in some regular ways. It could be small fleets of such as f.eg. mail carriers or local food deliverers. In accordance with the assumption about the communication based on short messages, the low bandwidth of the LoRa is not an important limitation.

The flow of information in Road traffic control system supported with system LoRaWAN is presented in the Fig. 3. In the proposed concept, the information about current exploitation parameters of the vehicle is continuously taken from On Board Networks and sent with CAN interface to part of device, which is responsible for preliminary data analysis. On the base of the data, the device prepares messages incorporating the information about the dynamic of movement f.eg. temporary accelerations, decelerations, average velocity, number of stop / start, activity of ABS etc. The formulated messages are periodically sent to the server with use of the LoRaWAN gates. In case of the arising events evaluated by pre-processing device as a critical a transmission can be released immediately. Actual data processing takes into account the information taken from other data sources such as f.eg terrestrial points of measurement. The final result of the data processing can be broadcasted or delivered to end point user. In opposite to solution like Yanosik all this happens automatically without driver activity.

6. Summary

The road conditions information from mobile objects being the participants of the traffic can significantly help to improve the real image of the road situation built on the base of stationary devices monitoring of road. Thanks to long range and low costs of the application of LoRaWAN it could be possible to use modern road-safety solutions in the areas where the communication network infrastructure is not very developed.

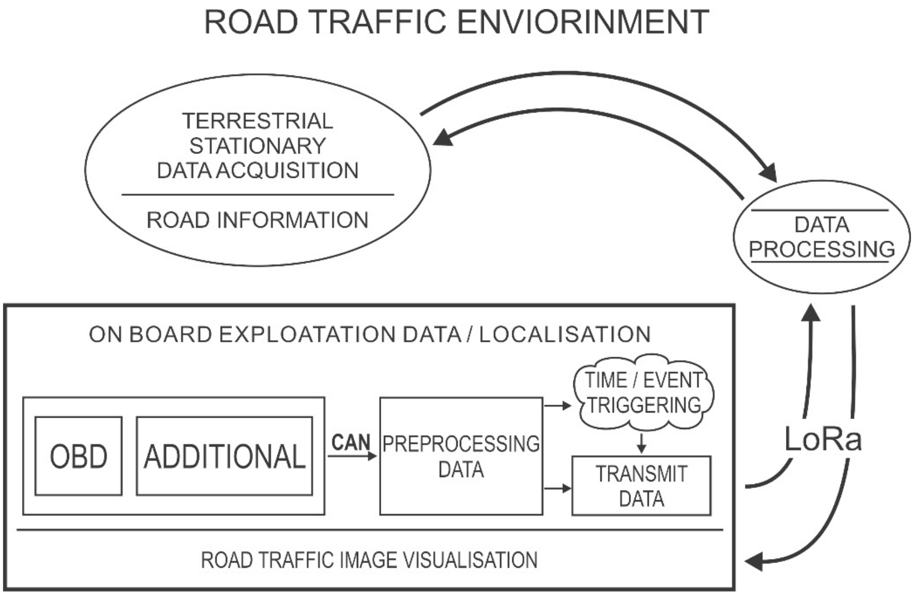

Fig. 3. The flow of information in Road traffic control system supported with system LoRa

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Manuscript received 25 May 2018; approved for printing 30 August 2018