DESIGN OF COMMUNICATION SYSTEM AMONG MOVING VEHICLES

Marian Klampár, Juraj Szőcs

Doctoral Degree Programme (1), FEEC BUT

E-mail: xklamp00@stud.feec.vutbr.cz, xszocs00@stud.feec.vutbr.cz

Supervised by: Karel Liedermann

E-mail: liederm@feec.vutbr.cz

Abstract: Communication between the vehicles themselves and between integrated systems is very important. Not only for the flow of road traffic, but especially for road users safety. This article will explore the technologies that can be used for communication and will demonstrate their advantages and disadvantages. It will further address the main problems that appear, like secure communication channel, the price of equipment and technology characteristics. It also looks at comparing technologies EDGE, WiMAX, ZigBee 802.11p. And finally simulation of selected technology in the program NCTUns will be mentioned.

Keywords: EDGE, ZigBee, 802.11p, WiMAX, WLAN, Security, V2V, V2X, NCTUns

1. INTRODUCTION

This article deals with a problem of communication between moving vehicles, describes technologies of wireless communications and its possible application in the designed system. For better safety in traffic we could use different methods like for example traffic signs, radar systems inside a vehicle or on them. This article addresses method which is considerable for the best from the sides of safety, flow of traffic and lower accident rate. Communication between the vehicles helps for safe queue-jumping and lowering a number of accidents. There are about 300 millions of registered drivers in state of Europe Union. The intensity of traffic was tripled for the last 30 years. Every year in traffic accidents on European roads die about 40 000 and injure about 1.7 millions of people. Insurance companies evaluate annual losses issued with traffic accidents to 200 milliards euro, with resulted traffic jam and complications to 50 milliards euro. Today's presumptions indicate that by 2020 the requirements for individual transport will be increased by 32% [1].

2. COMMUNICATION CAPABILITIES

Under capabilities of communication, we understand what technologies we can use for communication between vehicles. Scientists started to deal with the communication between vehicles long time ago but technologies were not sufficient enough and expensive. That is the reason what made them wait for better technology, which could be sufficient enough and cheaper. Currently, wireless technologies have done a huge leap in the field of wireless communication. This article deals with only few wireless technologies which could be used for the designed system.

2.1. EDGE

The GSM technology could be used for the communication between vehicles with just minor changes in a function of special modules. The GPRS could be used for the purpose of transmission and receive, which is currently used for the transmission of data. This technology is highly dependent on the movement speed of a mobile station. With a higher speed of movement occurs the Doppler phenomenon. Figure 1 shows this phenomenon. It is more reasonable to use the EDGE technology instead of the GSM because the phenomenon itself could be detected only with the

speed above 200 km/h [2]. Module price is very favourable and also the communication security is good, only weakness in security is the Base Transceiver Station (BTS).

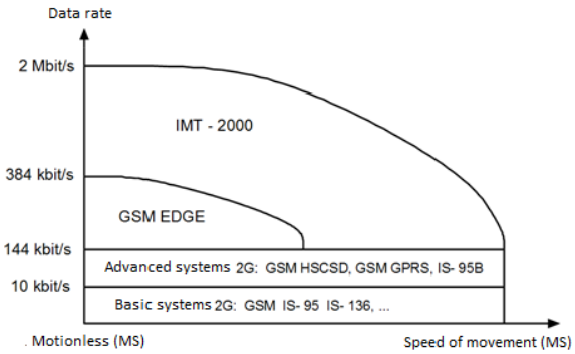

Figure 1: Data rate of speed of movement of MS [2].

2.2. ZIGBEE

The wireless sensor network ZigBee comes with the signal range up to 40 km. ZigBee technology is a quite new standard based on IEEE 802.15.4. ZigBee similarly like Bluetooth is designed for connecting low-power devices in personal are network - PAN. If ZigBee uses the multi-hop Ad-Hoc routing it allows for devices to be able to work for larger distance then the radio visibility of each devices. Transfer rate reaches from 20 to 250 kb/s. Signal is modulated with the O-QPSK BPSK method for a date transfer and transferred by direct-sequence spread spectrum – DSSS. Access to the physical medium is controlled by CSMA/CA method. One of the many advantages of ZigBee devices are low-current demands, with the running battery of AAA type its capable last from 6 months to 3 years and with a solar panel it could theoretically last forever. Zigbee device could work even for a greater distance then radio visibility of individual devices with the use of multi-hop Ad-Hoc routing. Supported date rates are from 20, 40 to 250 kbit/s. With Data rate is signal modulated with O-QPSK BPSK method and it is transferred by DSSS method. Access to a physical layer is managed by a CSMA/CA. One of many advantages is that devices have low energy usage and with a battery type AAA they are capable of last for 6 months to 3 years of usage. If these devices are mounted by solar panels they could last almost forever.

2.3. WIMAX

This is relatively a new wireless system. Success of the wireless networks IEEE 802.11 standard (mainly IEEE 802.11b standard, group WECA – Wireless Compatible Alliance, WiFi standard) defines wireless communication mostly for a usage in computing. According to information in the literature the WiMAX [2] (Worldwide Interoperability for Microwave Access Forum) is an organization that supports broadband wireless networks. WiMAX supports protocols IPv4, IPv6, ATM, Ethernet and etc. Spectral efficiency reaches 5 b/s/Hz and considerably exceeds the value of existing systems (for example 802.11a reaches 2.7 b/s/Hz). IEEE 802.16 standard was originally designed as a connection to the line of sight.

2.4. 802.11P

This standard is under development of IEEE and it is named by 802.11p. As first supports mobile connectivity for a connection of radio stations in cars to a motionless wireless access points. The whole system of the communication is built on DSRC. [3] DSRC allocates communication with a short range, it is simplex or duplex short to middle long ranged wireless communication channels, they are especially designed for usage in automobile industry. In the 1999 federal communication commission (FCC) assigned spectrum bandwidth of 75 MHz in USA and 5.9 GHz for DSRC in the intelligent traffic system (ITS). The European Telecommunications Standards Institute (ETSI) in Europe in 2008 assigned 30 MHz in a 5.9 GHz spectrum bandwidth. Decision about the bandwidth usage in 5GHz is optimal, because of the ability to spread in spectral environment, which optimal

for usage in an automobile environment. Waves spreading in this environment could offer higher data rate with communication to a long distance (to 1km) with a low dependency on weather. Currently the main usage of the 802.11p standard in Europe and Japan is as an electronic toll collection. DSRC system is not compatible with each other in Europe, Japan and USA and that is the reason why was the standard 802.11p created. Following text will deal with each parts of the 802.11p standard [4]. The system has three main parts: on-board unit (OBU), roadside unit (RSU) and intelligent traffic system (ITS). On-board unit (OBU) is a transmitter with a receiver constructed on principle of dedicated short-range communication (DSRC), this part of the system is mounted usually to the interior of a car or on the car itself. Roadside unit (RSU): it is a dedicated transmitter with a receiver of a short-range communications (DSRC), which is mounted along the road or pavement (RSU). Also it could be mounted on a vehicle or carried in the hands but it can work only if the unit is stationary. RSU is limited with a place, where it could be used by license. Intelligent traffic system (ITS) is a system that is collects information from RSU which receive information from OBU. This information is processed by individual needs and the purpose for which they are intended. The actual workflow is showed on figure 2.

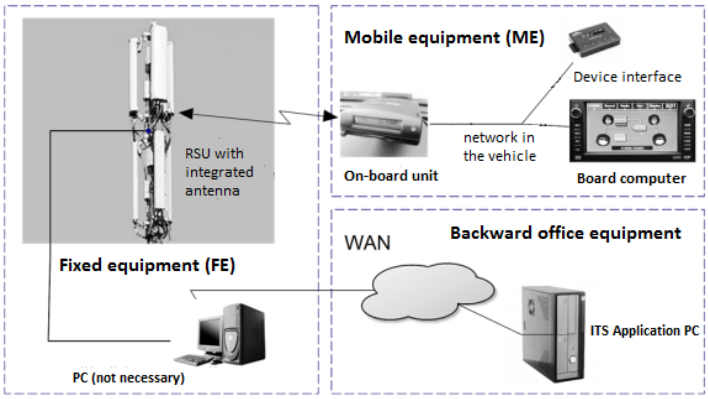

Figure 1: Individual parts of the IEEE draft 802.11p standard.

3. ANALYSIS OF COMMUNICATION BETWEEN VEHICLES

Along with the study of the best possible used technology we were find a study [5]. For the analysis were chosen already mentioned technologies. Each of them was compared with each other parameters, pros and cons.

3.1. APPLICABLE TECHNOLOGY

For purposes of communication between the vehicles were used the following technologies:

802.11p – Wireless technology based on 802.11a,

ZigBee – sensor network with very interesting specifications,

WiMAX – Wireless technology based on Wi-Fi, made directly for creating wireless connections,

EDGE – is currently the most widespread GSM network for mobile communications based on GPRS.

3.2. TRANSMISSION PARAMETERS

Requirements for a transmission depend mostly on an ability to deliver a message in the shortest period of time, under ideal conditions in real time. According to the table 1 communication between vehicles does not take too much bandwidth, it only takes 0.25 kb/s for ZigBee. The congestion of communication channels comes in heavily populated areas, where is a bigger activity of vehicles and that is why the communication alone should have possible the lowest

recommendation for a bandwidth. Problems with sending and receiving messages could be resolved by sending small amounts of data.

PARAMETER	WIFI 802.11	EDGE	ZIGBEE 802.15.4	WIMAX 802.16A
Transfer rate	to 54 Mb/s	100-150 kb/s	0.25 kb/s	to 134Mb/s
Modulation	BPSK OFMD QPSK OFMD 16-QAM OFDM 64-QAM OFDM	8-PSK	BPSK O-QPSK	BPSK OFMD QPSK OFMD 16-QAM OFDM 64-QAM OFDM
Memory requirements	100 + KB	100 + KB	32-60 KB	100 + KB
Range	to 1000 m	depends on coverage	10 m to 40km	40-70 km
Energy consumption in standby mode	20 mA	25 mA	3 μA	10 mA
Energy Consumption	400 + mA	300 mA	35 mA	330 mA
Price	to 1000 CZK	400 CZK	1500 CZK	1200 CZK

Table 1: Comparison of protocols.

Table 1 shows that all analyzed protocols are similar to each other and all could be used for the communication. Each analyzed protocol has its pros and cons. WiMAX has a good range and now it is used as a Metropolitan network. ZigBee is a wireless sensor network has a weakness against other wireless technologies concretely a possible packet lossless which is crucial for our designed system. Packet losses could influence the road traffic safety that is why can not use this technology. The main advantage of ZigBee is in a minimal voltage recommendation, with help of sun collectors it could be a network with a minimal voltage demanding. EDGE got its main advantage in an area that could be covered, thanks to the expansion of GSM almost 100 % in Czech Republic is covered and the price of a module costs about 100 CZK. IEEE 802.11p is a standard created especially for communication between vehicles, its reliability is not verify yet but already now it is know that it is not designed for the multimedia support.

4. SIMULATION

In the simulation environment of NCTuns v6.0 was created a simulation with mutual wireless communication of vehicles according to the above information. NCTuns is a simulation environment dedicated for network simulations which supports different types of wireless or wire technologies. One of the main features is displaying the results of simulation into charts. It is capable to simulate many technologies like 802.11(a, b, e, p), GPRS, DVB-RCST Satellite, 802.16 (d, e, j), ITS, QoS, heterogeneous and also optical networks. Many other features of the simulation environment and all useful information can be found on the website [6].

4.1. NCTUNS

Figure 3 shows a simulation of 100 vehicles in one cell. The result of the simulated scenario was a discovery that one cell could mutely communicate maximally with 100 vehicles. Scenario with more than 100 vehicles per cell resulted in overwhelmed communication channel.

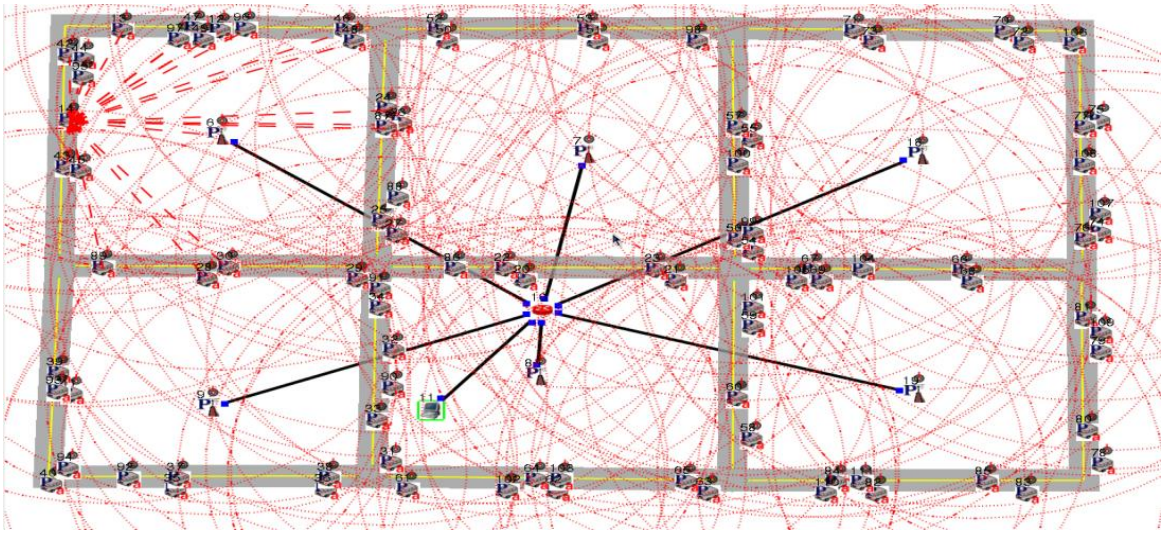

Figure 2: Wireless communication in one cell with 100 vehicles and six APs.

5. CONCLUSION

The main idea of this article was to explore different types of wireless technologies and choose the best solution for the designed V2V and V2X system. The designed system should prevent an undesired collision of vehicles with a mutual exchange of important data. It should provide a safer way to queue jump in heavy traffic. From the overall review we picked one the most suitable method to solve the communication among moving vehicles and that method is Zigbee. Zigbee is the most suitable method for the communication among vehicles because it has low energy cost, big range and acceptable transmission rate. The biggest problem could appear if a vehicle does not have a device that support this technology or the device not going to work properly. This state could be minimized if the system every time verifies the system state and functionality. Vehicles without capability of this system are showed in figure 3 as grey colored vehicles. This system should be presented not on the experiment level but on the legislative level as mandatory equipment. This specific field is currently under research.

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