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WLAN -wireless local area network, V2V-vehicle- to-vehicle, VCA- vehicle collision avoidance, MOPE- mobile platform of Europe, OFDM – orthogonal frequency division multiple access

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USING AD HOC WLAN TO VEHICLE COLLISION AVOIDANCE

In this paper we present an initial study of wireless networks application to vehicle safety issues. In particular, we estimate communication range, throughput, latency and packet losses in Ad Hoc 802.11b network. We develop an idea of vehicle-to-vehicle communications (V2V) and the form of its using to collision avoidance. According to this idea the special alarm packets are emitted backwards from a crashed or braking vehicles- being in the front of the column - to other vehicles. This idea was submitted to the International Project MOPE in the frame of FP6/eSafety/2.4.12.

WYKORZYSTANIE SIECI WLAN DO PRZECIWDZIAŁANIA WYPADKOM DROGOWYM

W literaturze fachowej ostatnich lat podnoszony jest problem tzw. vehicle collision avoidance (VCA) -przeciwdziałania wypadkom drogowym. W referacie rozważa się możliwości zastosowania sieci Ad Hoc WLAN, np. 802.11b,a,g,e do przesyłania specjalnych pakietów alarmowych. Takie informacje byłyby przesyłane od pojazdów jadących z przodu w kierunku do tyłu i zawierałyby dane o przypadkach hamowania lub aktywacji poduszki powietrznej. Praca znajduje się na etapie wstępnym, symulacyjnym w NS-2/Linux. Temat ten został zgłoszony do międzynarodowego projektu MOPE w ramach FP6/e-Safety/2.4.12.

1.INTRODUCTION

There has been increasing interest in exploiting information technology advances (e. g .,mobile computing and wireless communications) in area of transportation systems. An emerging trend is to equip vehicle with computing communication capabilites (e.g. RADAR, GPS, WLAN, EDGE). Proposed applications that are designed to benefit from in-vehicle systems are generally classfided as falling into safety and non-safety categories. Safety applications include collision warning and avoidance, automated enforcement, semi – automated vehicle control etc.[5]. Non-safety application include traffic information

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propagation [10], traveler and tourist information, ETC*(Electronic Toll Colection)*, internet access [3]. In most of these applications, V2V communications can play a critical role. We differ four methods in V2V communication:

- broadcast- from a single vehicle to neighbours,
- multi-hop [6] ,
- one-hop [1],
- V2V system with priority.

The author of this paper describes the point- to- multipoint with differentiated service for use in safety applications.

2. WLAN NETWORK AND ICT POTENTIAL

WLAN basing on 802.11b,a,g standards can operate independently as dedicated network to execute Vehicle-to Vehicle communications (Fig.1). This modest architecture is simple and chip, but for other applications isn't insufficient. For driver assistance, navigation, entertainment, data exchange between running vehicles and LAN, different services use AP (Access Point), gateways, satellite connections (e.g. FleetNet [6] project, DSRC (*Dedicated Short Range Communications*) [1] [5].

ICT -*(Information Communication Technology)*

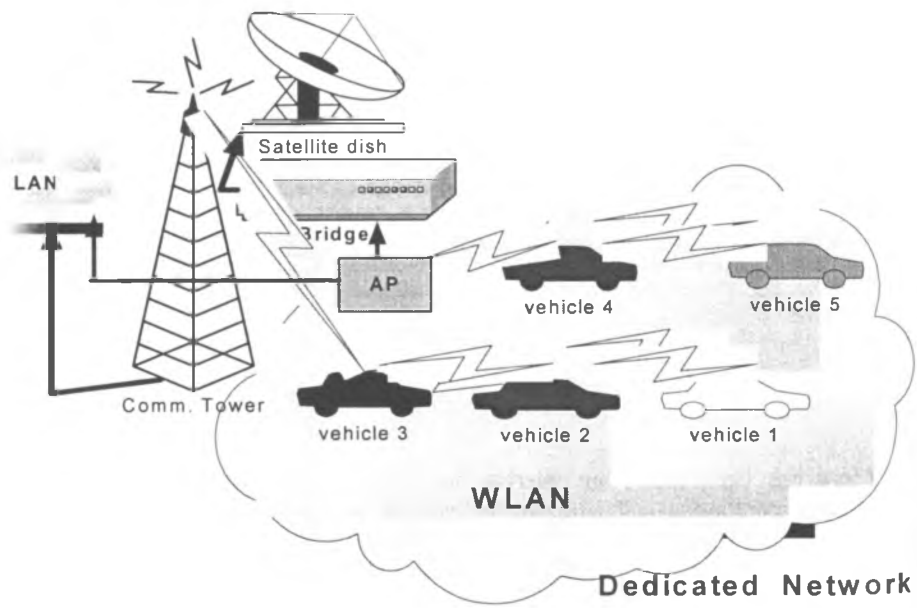

Fig.1. Deticated network WLAN can work independetly

3. SIMULATION STUDY OF 802.11b

Network 802.11b was examined in NS-2 simulator . For TCP, UDP signals the throughputs and latency is estimated. The Two-Ray Ground and Shadowing propagation models is used. Simulation details are described in [6],[7]. The tests of simulation were conducted by driving through various conditions: dense network, speed the nodes 20m/sec and different routing protocol: DSDV, TORA, AODV, DSR.. DSDV *(destination sequence distance vector*) and DSR(*dynamic source routing)* were more efficiently then others. The rates of transmission depends on type the protocol. Latency for intercommunication message was about 150ms.

4. IDEA OF V2V COMMUNICATIONS

The directional antenna of lane 1 (S- sender) gives ALERT signal for the cars moving ahead. The waves of radios have an influence neglegible for others, which move in opposite direction on highway. Fig.2 corresponds to proposed communication system. In this diagram sender determines range of transmission. The distans between moving cars is assumed as 56m and 4m for length of car (dense network). Fig.3 describes a scenario with the obstacle and the driver's reactions. Fig.4 describe similarly scenario in domain of the time. It is possible in 802.11 a standard to apply antenna of gain 30dB and achieve a range about 1000m.

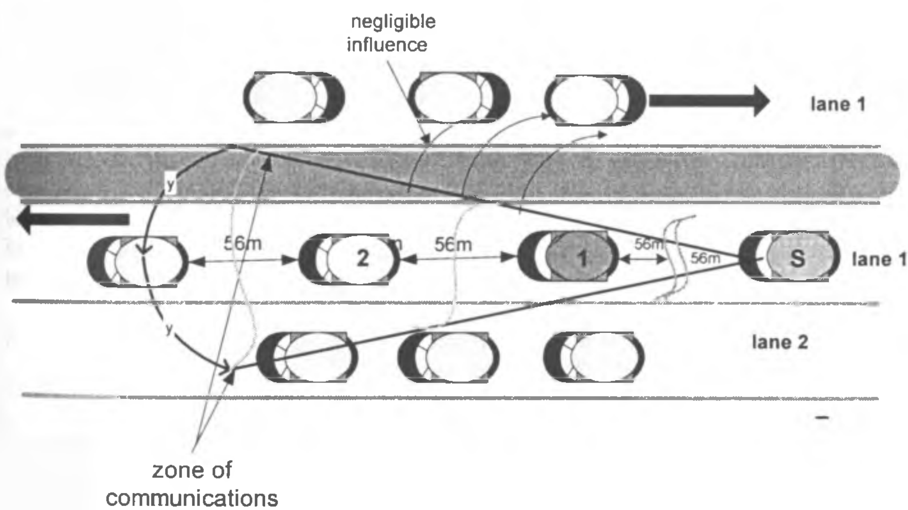

Fig.2. A typical arrangement of vehicles along a road

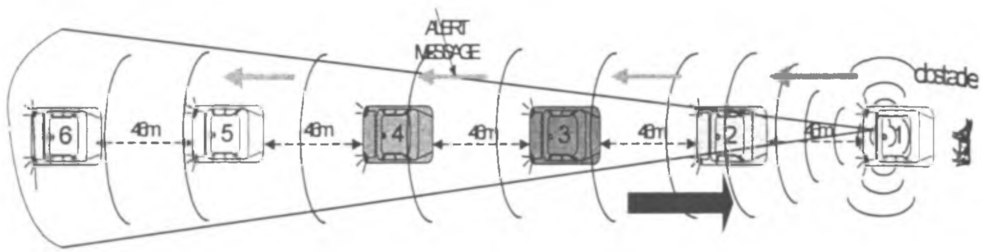

Fig.3. The mechanism of collision avoidance owing to the extending range of sight via WLAN

V2V system based on point–to-multipoint partial communication with DIFFSERV mode. It is favorable to apply WLAN, because these networks are very popular, give much different communication possibilities, modes of transmission through different routing protocol, power level and mode of modulation.

We consider WLAN 802 11b, but range of communication (about 200m), throughput in dens network is small – from 3Mbits/sec fall to << 1 Mb/sec. Moreover this "phenomenon " cans employment to an image of road traffic, indirectly to safety. In this case we propose 802 11a standard with largest communication range and [9] OFDM or 802 11 g with OFDM and max. Theoretical rate 54Mbit/sec. Why OFDM - *Orthogonal Frequency Digital Modulation*? Because of its well-know ability to avoid multi-path effects while achieving high data rates and channel capacity. The other feature of this modulation is resistance to selective fading and narrow noise. BER *(Bit Error Rate)* for OFDM 802.11a with Nakagammi propagation mode is as low as 10^{-12} [4].

The main objective of VCA is to reduce the number of victims and injured persons. The goal of the action is to reduce the time transmission of information and to get BER = 10^{-6} *in* various conditions. Usually, in classical road systems follower observe a leader. It is create a chaine leader-follower, but the drivers take far positions haven't time to stop. The driver with WLAN is able to see approximately ten times farther than by his eyes indecently of whether conditions, day and night. It is very important to give a chance to avoid collision. In this case the time is a critical parameter for reaction of driver. In any case used of brakes or air-back explosion in the vehicle far ahead the given vehicle, the alarm message will be transmitted.

In addition the following safety related advantages from the GIS point of view have been identified and will be refined during the user requirement definition phase:

- Transport of hazardous materials:
  - warning the driver if entering a restricted area
  - Guidance possibilities/warning, e.g. truck to heavy for bridge ahead or truck to high for tunnel ahead
  - tracking of vehicle with control centers, e.g. police knows location of accident in case of accident or other events witch might make it necessary to redirect the vehicle with hazardous materials

    accident warning if accident is ahead of route

- Vehicle-to-Vehicle communications:
  - exchange of up to date traffic information, e.g. traffic jam ahead or flooded road, even if there is communication to the control centers available currently.

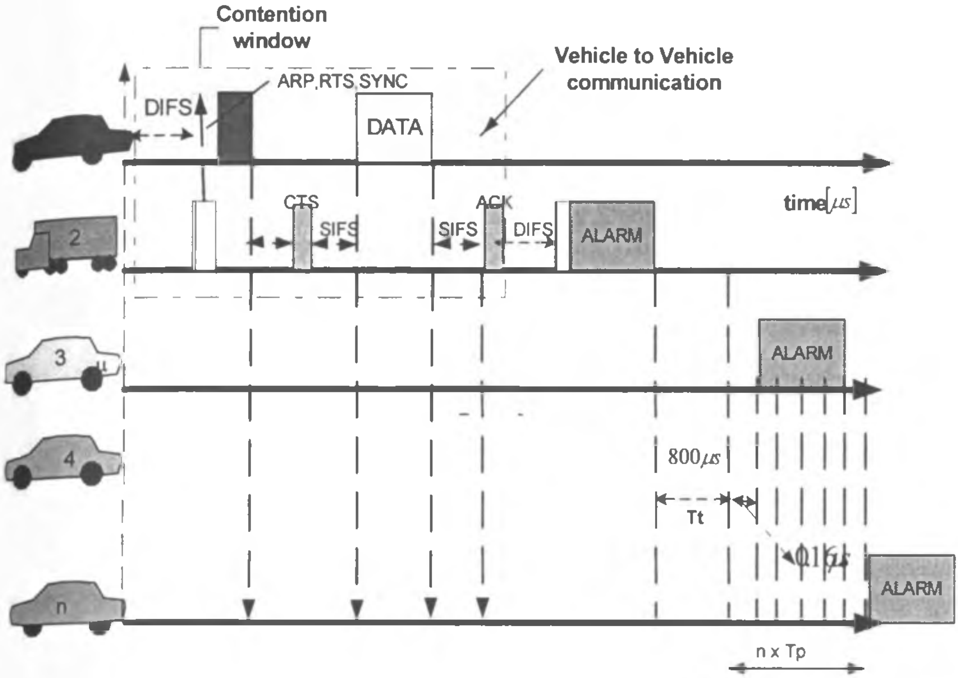

Fig.4. Vehicle-to-Vehicle communications in time domain. Alarm packets are generated from vehicle 2 to other

Typical control signals used in standard 802.11 – DIFS-(*Distributed Coordination Function interframe Space*)
SIFS- *(Short Interframe Function Space)*
ARP- (Address Resolution Protocol), RTS-*(Rest to Send*)
CTS- (Clear to Send), ACK-(*ACKNOWLEGEMENT*)

The DIFS is used to choose the mode of transmission, giving a higer priority to the former. The width of CW*(Contention Window*) depends on the value of slots time. (one slot is min. time of CW). In typical scenario V2V communications is based on general assumption that, the acces to the chanell is reached by a client of network with the shortes CW. The priority system breakes the normal communication between cars. The routing algorithm for priority (in case of the possible crash) rejects routers signals as CTS, RTS and ACK.

5. CONCLUSION AND FUTURE WORK

In previous works, information propagation through multi-hop forwarding or mobile node movement was examined [8]. In 802.11b network for assumed channel modeless (discussed above), fading, scattering is typically used to describe mobile scale channel characteristics. It seems, that classic channel models (Free Space, Two-Ray Ground) are not representative ones. The Shadowing model (of log-normal distribution) is approached real conditions. Our future work will go in several directions. We will study the model of traffic. A simplified model is presented in Appendix A. The most advanced models are in course. The goal of this subject is to find a connection between communications and movement of cars. In domain of communications we will follow the abroad researches, e.g. [2], [3].

Appendix A

A simple model of road traffic

The modeling of traffic is needed for the design of communications system V2V [3]. Let a mean rate of crossing the given point on a road by vehicles be □ and a speed of vehicles be v (e.g. 1/2s and 30m/s). Let the distance between vehicles be d (e.g. 0m) and vehicle's length D (e.g. 4m). Then, in regular traffic (d and v constant) we obtain along a lane of length L (e.g. 1000m) the stream of x vehicles ($x=L/D=250$). Now, let us suppose the traffic obeys Poisson law

$$P(K-1)=\frac{(\lambda\tau)^{K-1}}{(K-1)!}e^{-\lambda\tau} \tag{1}$$

where τ is a safe distance at a given speed v, say 60m and K – number of vehicles in τ.

This assumption means that the regularity of crossing can now be disturbed and may cause crashes. Let us make some calculations and simulations. If the speed is 30m/s, the safety distance takes a time τ=60/30=2s. This is our Poisson window. The exponential distribution with a mean time τ=2s is shown in Fig.1A and Poisson distribution in Fig.6. We see in Fig.5 the random times are: 0.4943 0.0964 2.2718 2.2745 5.4573 0.9674 1.4655 3.5553 seconds. They cause the vehicles to bring closer or farther in comparison to standard distance (60m, 2s) and trigger off the crashes. To avoid them, some vehicles should be taken out of the stream by decreasing the intensity λ. Taking into account the similar analysis in packet communications [11] we suggest a relation

$$\rho=Ge^{-G} \tag{2}$$

where G- normalized traffic rate in regular movement, ρ- traffic rate due to random distribution.

The ρ gets its maximum value at G=1 and then ρ=1/e. It means that a number of vehicles in a length L are reduced by a coefficient of 1/e≈1/3. It means that instead of 1000/60=17 vehicles we place on a lane of length L only ~6, see Fig.1A. In a real situation Poisson low is not obeyed, because drivers observe neighbors and take a proper reaction. This may be expressed by a correlation function or filtration of the generated stream via a low-pass filter. An example of is given in Fig.6.

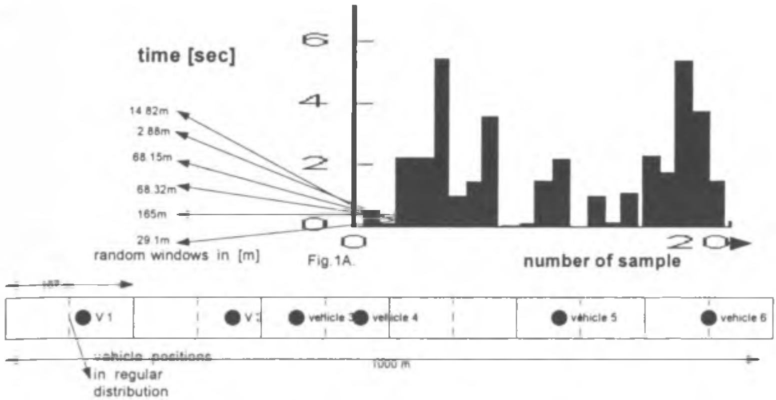

Fig.5. Run of exponential distribution and its transformation to vehicles distribution

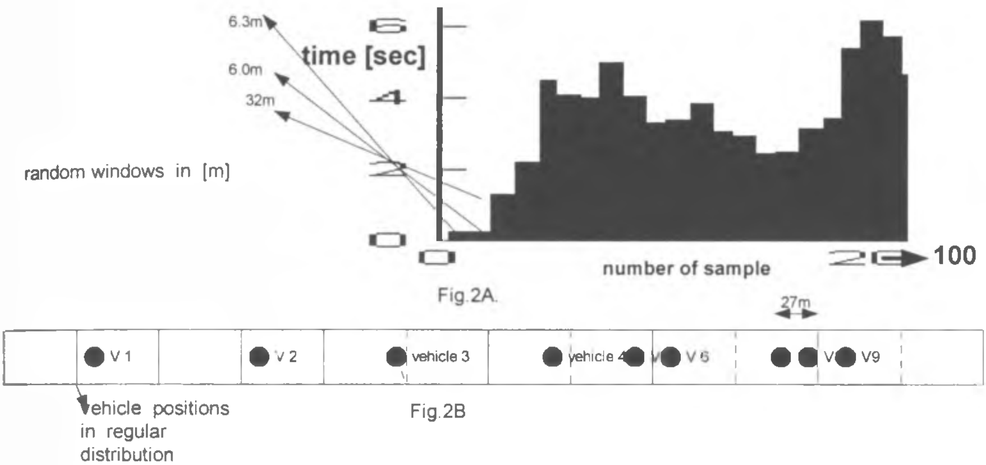

Fig. 6. a) the run of fig 1a after correlation via low pass FIR filter a=0.5, b=[1 –0.8],
b) some results of simulation after correlation with coefficient equal to 0.57

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