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PERFORMANCE ENHANCEMENT WITH THE NEW IEEE802.11p (DSRC) IN VEHICULAR COMMUNICATIONS

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ABSTRACT

Active wireless communication between high speed vehicles, nowadays, is actually a very challenging problem and using advanced mathematics & signal processing methods, we can significantly increase the reliability of those systems. The technology has been developed now globally and is termed as Dedicated Short Range Communication (DSRC). For DSRC, IEEE has made a new protocol IEEE802.11p with some amendments in the previous IEEE802.11a. In this paper we are using 802.11p for vehicular communications and the results of the paper show that this 802.11p is much better than 802.11 with better packet delivery ratio, less delay and some other improved parameters.

KEYWORDS: DSRC, 802.11p, 802.11, Packet Delivery Ratio, Delay, AODV, DSR, VANET, NS2

INTRODUCTION

Dedicated Short Range Communication (DSRC) combines wireless communication & GPS to give vehicles a 360° awareness of all the vehicles around them. An on board computer can use that information to provide the driver with warnings to help avoid collisions. It enables cars to share its positions to vehicles around it so that the cars autonomously make safety judgments about whether or not there is an impending threat from other vehicles which can alert the driver if any impending collision is likely. The cars share their positions very rapidly and it doesn't require that there's a line of sight between the vehicles. So the two cars could be around a corner and yet they'll be aware of each other's positions.

DSRC is a technology by some global standards. The spectrum that is used to do the communication is specifically for safety. That's an important point which means that the availability of signals from other vehicles is not going to be interrupted by some other kind of traffic in the network.

This technology involves sending both routine safety & event safety messages [1]. The former contains information about vehicle state, as position/direction and speed, and are regularly broadcasted by all vehicles. These messages constitute the majority of traffic and have a lifetime of a few seconds. While event messages are triggered by event situations such as sudden braking. These messages occur only occasionally but can contribute significantly to the traffic load on the control channel when they do occur. So, event messages have a more stringent requirement for fast and guaranteed delivery, whereas routine messages may tolerate some loss. The DSRC medium access control (MAC) protocol has a major effect on both the reception and the delay of safety messages [2].

IEEE 802.11p is a wireless communication protocol designed for vehicular ad hoc networks in order to support safety and commercial non-safety applications. The conventional 802.11 protocols are not suitable for these types of communication because of high vehicular mobility, faster topological changes, and requirements of high reliability and low latency for safety applications.

IEEE802.11p AMENDMENT DETAILS

IEEE group has developed a new PHY/MAC amendment of the 802.11 standard, which is designed for VANET communications which is referred as IEEE 802.11p. It is suitable for High speed Vehicle communication [3]. The requirement of this amendment is based on the vehicular safety concepts, communication between Vehicle to Vehicle and Vehicle to infrastructure. The Dedicated Short Range Communication (DSRC) at 5.9 GHz band allocated for the ITS communications uses the IEEE 802.11p. The most important requirements for a MAC protocol for VANET are low Latency and High reliability. At the PHY layer, the IEEE 802.11p works in the 5.850-5.925 GHz spectrum.

Code Fragment 1 shows the changes in parameter values for 802.11p PHY. The parameters' names are self explanatory.

```
Phy/WirelessPhyExt set CSThresh_ 3.981e-13 ;# -94 dBm wireless interface sensitivity

Phy/WirelessPhyExt set Pt_ 0.1 ;# equals 20dBm when considering antenna gains of 1.0

Phy/WirelessPhyExt set freq_ 5.9e+9

Phy/WirelessPhyExt set noise_floor_ 1.26e-13 ;# -99 dBm for 10MHz bandwidth

Phy/WirelessPhyExt set L_ 1.0 ;# default radio circuit gain/loss

Phy/WirelessPhyExt set PowerMonitorThresh_ 3.981e-18; # -174 dBm power monitor sensitivity (=level of gaussian noise)

Phy/WirelessPhyExt set HeaderDuration_ 0.000040 ;# 40 us

Phy/WirelessPhyExt set BasicModulationScheme_   0

Phy/WirelessPhyExt set PreambleCaptureSwitch_   1

Phy/WirelessPhyExt set DataCaptureSwitch_       1

Phy/WirelessPhyExt set SINR_PreambleCapture_ 3.1623 ;# 5 dB

Phy/WirelessPhyExt set SINR_DataCapture_ 10.0 ; # 10 dB

Phy/WirelessPhyExt set trace_dist_ 1e6 ;# PHY trace until distance of 1 Mio. km ("infinity")

Phy/WirelessPhyExt set PHY_DBG_ 0
```

Code Fragment 1: 802.11p PHY

Code Fragment 1 shows the changes in parameter values for 802.11p PHY. The parameters' names are self explanatory.

```
Mac/802_11Ext set CWMin_                    15
Mac/802_11Ext set CWMax_                    1023
Mac/802_11Ext set SlotTime_                 0.000013
Mac/802_11Ext set SIFS_                     0.000032
Mac/802_11Ext set ShortRetryLimit_          7
Mac/802_11Ext set LongRetryLimit_           4
Mac/802_11Ext set HeaderDuration_           0.000040
Mac/802_11Ext set SymbolDuration_           0.000008
Mac/802_11Ext set BasicModulationScheme_    0
Mac/802_11Ext set use_802_11a_flag_         true
Mac/802_11Ext set RTSThreshold_             2346
Mac/802_11Ext set MAC_DBG                   0
```

Code Fragment 2: 802.11p MAC

ROUTING PROTOCOL

Addressing the challenges in vehicular communications has been the main focus work in this area. Effectively routing traffic with a more intelligent use of resources is a good way to cover these problems. We can say that good design of the routing protocol has the ability to improve performance because the transmission and dissemination of information are made according to the protocol. Routing is an essential parameter in VANETs or this is the first parameter to be studied. So here, we need a comparison to be made between AODV and DSR as we are more focusing on reactive routing protocol.

Ad hoc On-Demand Distance Vector (AODV) Routing is a routing protocol for mobile ad hoc networks (MANETs) and other wireless ad-hoc networks. It is a reactive routing protocol, meaning that it establishes a route to a destination only on demand. In contrast, the most common routing protocols are proactive, i.e. they find routing paths independently of the usage of the paths.

AODV is, as the name indicates, a distance-vector routing protocol. AODV avoids the counting-to-infinity problem of other distance-vector protocols by using sequence numbers on route updates, a technique pioneered by DSDV. AODV is capable of both unicast and multicast routing [4].

Dynamic Source Routing (DSR) is a routing protocol for wireless mesh networks. It is similar to AODV in that it forms a route on-demand when a transmitting computer requests one. However, it uses source routing instead of relying on the routing table at each intermediate device [5].

SIMULATION

We are using NS-2.35 which is the latest version NS-2 [6]. The NS2 simulation is visualized in the Network Animator (NAM) and Tracing Files stores all of the simulation information. NAM file can be used to view the output of the VANET simulation. The performance of the Mobility, Packet receiving time, sent data, received data, Throughput, Packet delivery ratio, sent packets, dropped packets and other information is measured by the NS2 trace file.

This version of NS-2 introduces two new modules: Mac802.11Ext and WirelessPhy-Ext. These two extensions are based on the default Mac802.11 and WirelessPhy. The PHY layer Parameters and MAC layer Parameters used in NS2 TCL file are modified as per the parameters of IEEE802.11p.

Scenario Characteristics

We have considered a scenario of 100 nodes distributed in 1000m x 1000m for 20 seconds of simulation. The packet type is Constant Bit Rate (CBR) with a seed of 1.0 and a rate of 4 packets/sec. The speed is uniform with a min. value of 20km/hr and a max. of 150km/hr which gives an average speed of 64.52km/hr. (These values, number of nodes, area of simulation, packet type, simulation time etc are taken as per need which can be changed or modified.)

RESULTS AND ANALYSIS

Packet Delivery Ratio (PDR)

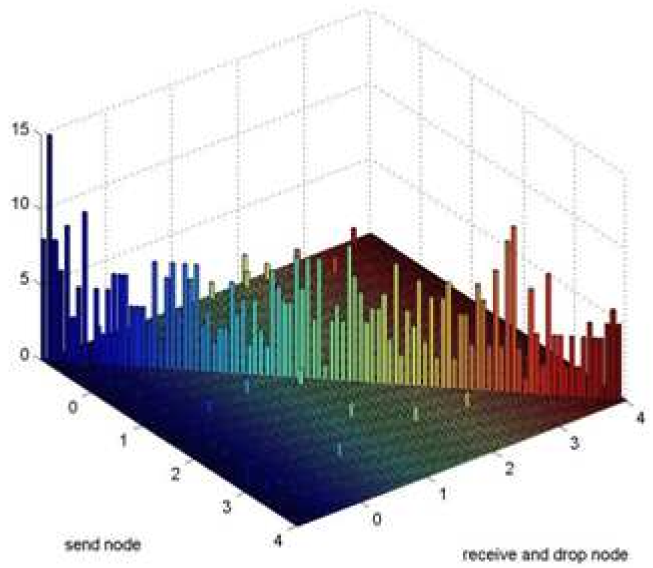

Figure 1: Number of Dropped Packets at all Nodes for 802.11 Using AODV

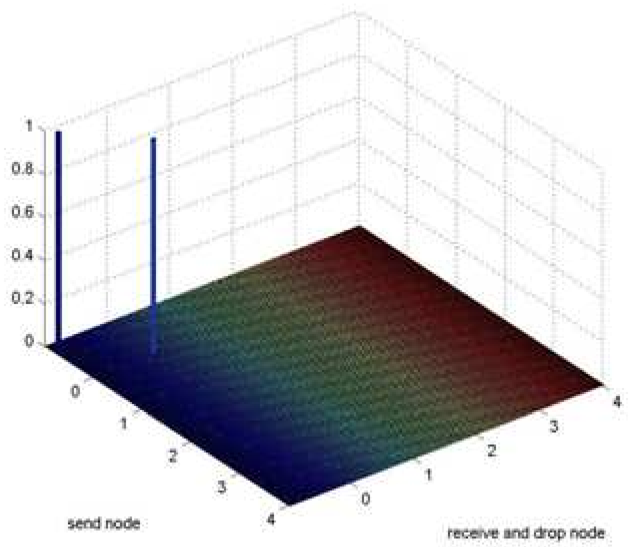

Figure 2: Number of Dropped Packets at all Nodes for 802.11p Using AODV

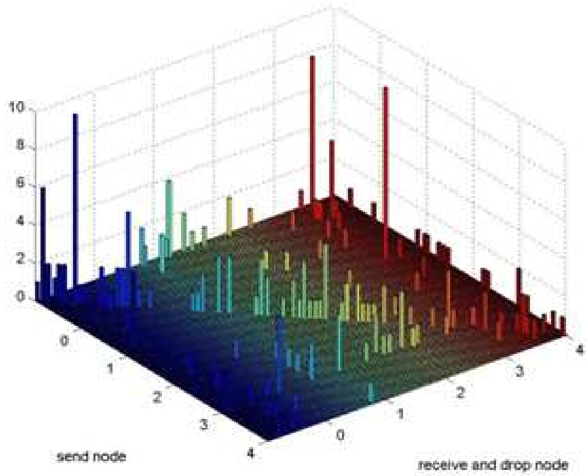

Figure 3: Number of Dropped Packets at all Nodes for 802.11 Using DSR

PDR is the ratio of the number of data packets received at the receiver to the total number of packets transmitted at the sender. Figure 1 shows the numbers of dropped packets at all of the nodes for 802.11 using AODV in a 3D view. Similarly, figure 2 shows the number of dropped packets for 802.11p using AODV. Figure 3 shows the number of dropped packets for 802.11 using DSR. Note that we have not attached the graph for the dropped packets for 802.11p using DSR because during the simulation, there was no packet drop for 802.11p using DSR. (This is because the simulation parameters are small. When it takes place for a large amount of time, obviously packets get dropped.)

Calculation of End2End Delay

Figure 4 shows the End2End simulation delay's cumulative distribution function for 802.11 using AODV, 802.11p using AODV, 802.11 using DSR and 802.11p using DSR. The main concern is to see the curve's sharp cut-off characteristics. From this figure, we see that 802.11p using DSR has best cut-off so it would have better response, i.e. less delay. The exact values of all these are shown in the next upcoming figures.

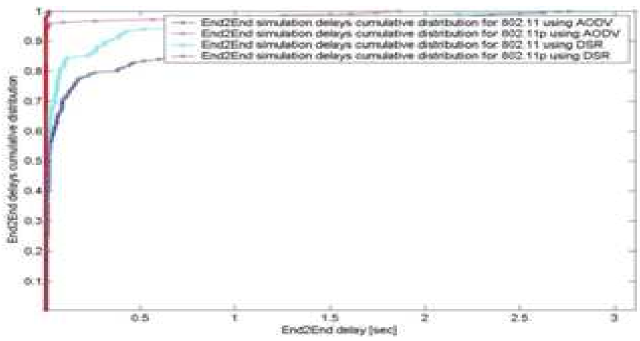

Figure 4: End2End Simulation Delays Cumulative Distribution

Simulation End2End delays in seconds:

Minimal delay (CN,ON,PID):	0.005497225 (1,2,19)
Maximal delay (CN,ON,PID):	2.758889162 (79,80,158)
Average delay:	0.2843700765

Figure 5: Simulation End2End Delay for 802.11 Using AODV

Simulation End2End delays in seconds:

Minimal delay (CN,ON,PID):	0.001594235 (77,78,39)
Maximal delay (CN,ON,PID):	1.859337945 (1,2,0)
Average delay:	0.04390784163

Figure 6: Simulation End2End Delay for 802.11p Using AODV

Simulation End2End delays in seconds:

Minimal delay (CN,ON,PID): 0.005517097 (77,78,118)
Maximal delay (CN,ON,PID): 3.106454312 (1,2,712)
Average delay: 0.1515069517

Figure 7: Simulation End2End Delay for 802.11 Using DSR

Simulation End2End delays in seconds:

Minimal delay (CN,ON,PID): 0.001594223 (7,9,60)
Maximal delay (CN,ON,PID): 0.018385763 (77,78,22)
Average delay: 0.001960838557

Figure 8: Simulation End2End Delay for 802.11p Using DSR

Other Simulation Information

Figure 9 shows other information about the parameters during the simulation of 802.11 using AODV.

Simulation information:

Simulation length in seconds:	17.44316112
Number of nodes:	100
Number of sending nodes:	100
Number of receiving nodes:	17
Number of generated packets:	4666
Number of sent packets:	4166
Number of forwarded packets:	333
Number of dropped packets:	524
Number of lost packets:	0
Minimal packet size:	32
Maximal packet size:	532
Average packet size:	57.0841
Number of sent bytes:	299352
Number of forwarded bytes:	142020
Number of dropped bytes:	39524
Packets dropping nodes:	0 1 2 3 4 5 6 7 9 10 1

Figure 9: Simulation Information during the Simulation of 802.11 Using AODV

For other simulations as well, we have the parameters as shown in figure 9. Extracting information from them, we made this following table 1 which shows all important parameters for all of the simulations.

Table 1: Results with AODV and DSR for 802.11 and 802.11p

	AODV		DSR	
	802.11	**802.11p**	**802.11**	**802.11p**
Number of generated packets	4666	923	1436	243
Number of sent packets	4166	921	1344	243
Number of forwarded packets	333	0	1297	0
Number of dropped packets	524	2	213	0
Number of lost packets	0	1	361	1
Number of sent bytes	299352	152120	247640	123732
Number of forwarded bytes	142020	0	357722	0
Number of dropped bytes	39524	88	53122	0
Packet delivery ratio	80.80	98.67	60.81	99.57
Simulation End2End delay (sec)	0.2843	0.0439	0.1515	0.00196

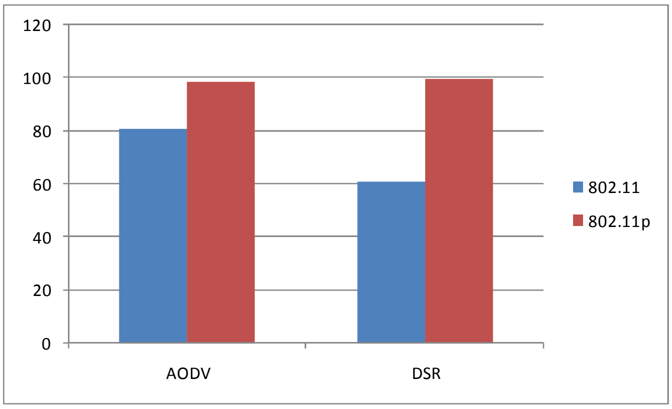

Figure 10: PDR for AODV and DSR Using 802.11 and 802.11p

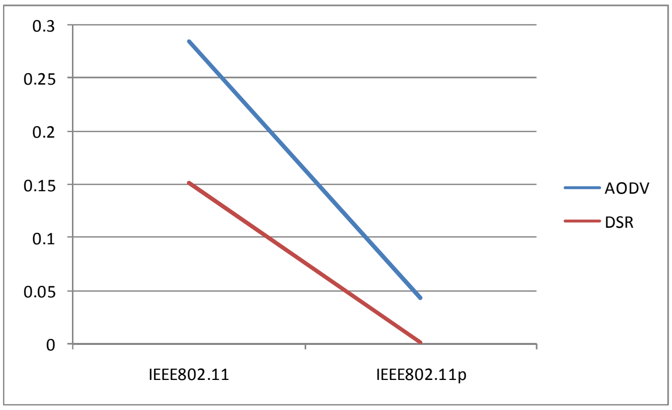

Figure 11: End2End Delay for AODV and DSR Using 802.11 and 802.11p

Figure 10 shows the graph of packet delivery ratio for AODV and DSR using 802.11 and 802.11p, which shows that 802.11p has much better PDR than 802.11.Similarly, figure 11 shows the End2End delay for 802.11p is less than 802.11 (which is desired.)

CONCLUSIONS

The very high speed of the nodes (up to 250 km/h), traffic and the large dimensions of the VANET are more challenging problems in recent research areas. So IEEE has dedicated a new, discrete standard 802.11p for vehicular communications with some amendments in the previous standard. In this paper we used both of the standards and analyzed their performance. We also obtained the performance of two major routing protocols AODV and DSR by having 802.11p PHY and MAC parameters in VANETS. The results show AODV and DSR under 802.11p and 802.11with enhanced performances showing less delay, high throughput, better packet delivery ratio and other enhancements in the parameters which is a plus point for vehicular communications.

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