Performance Evaluation of Path loss Exponents on Rate Algorithms in Vehicular Networks

Kenneth Sorle Nwizege, Michael MacMammah, Godson Ivbuobe Ikhazuangbe

Abstract*— One of The major drawbacks for mobile nodes in wireless networks is power management. Our goal is to proposed a power control scheme that will help minimize energy consumption by appropriate adjustment of vehicles transmitter power, reduce network congestion, improve quality of service and collision avoidance in vehicular networks. Some of the importance of power control (PC) is improving spatial reuse, and increasing network capacity in mobile wireless communications. In this simulation we have evaluated the performance of existing rate algorithms compared with ACARS. Results show that ACARS is able to minimize the total transmit power in presence of of propagation processes and mobility of vehicles, by adapting to the fast varying channels conditions more than the other algorithms, which has some applications in vehicular networks as mentioned above.

Index Terms*—DSRC; Wireless networks; Mobility;Vehicular communication; IEEE 802.11p;Rate adaptation ;Propagation, Power control, Fading;

I. INTRODUCTION

Dedicated Short Range Communication (DSRC) is the communication standard for vehicle-to vehicle(V2V) and vehicle -to-infrastructure (V2I) radio frequency communication links solution for mobile data broadcast and also to active Wireless Access to Vehicular Environment(WAVE) protocol. It is a short to medium range communication service that supports applications like: electronic toll collection and public safety, which needs high data rate and low latency [1,2]. In order to provide opportunity for DSRC to deploy its aims in the future for V2V and V2I, the IEEE is currently working on the IEEE 802.11p WAVE standard. IEEE 802.11 protocol specification allows multiple transmission rates at the physical layer (PHY) using different modulation and coding schemes. Vehicular communication techniques use 802.11p wireless standards. It offers eight bit rates ranging from 3 - 27Mbps from which the transmitter can choose. 802.11p is based on Orthogonal Frequency Division Multiplexing (OFDM) to compensate for both time- and frequency-selective fading [2].

Rate adaptation is a link layer mechanism critical to the system performance in IEEE 802.11 Wireless Local Area Networks (WLANs) [1]. It is the process to choose the best rate for the current channel condition. The goal is to maximize the throughput via exploiting the multiple transmission rates available for 802.11 devices and adjusting their transmission rates dynamically to the time-varying and location dependent wireless channel conditions.

Power control is an efficient technique to combat the effect of multipath fading which affects received signals in wireless networks. In vehicular communication, these effects are common due to tall buildings, trees that are spread over roads as vehicles moves from one destination to the other. In other to combat this effect, a proper power control type need to be adopted in order to mitigate this challenges.

Controlling the transmit power of mobile communication is a very efficient means to control the quality of service (QOS) and the capacity of wireless networks [39,40] . In environments where the channel varies slowly, existing power control schemes are designed to operate in such networks, but when it comes to channels like vehicular networks it does not perform well because user channels changes very quickly and these methods fails in such scenario. Power adjustment is needed in this case rather than tuning the instantaneous Signal to Interference and Noise ratio (SINR).

The rest of the paper is organized as follows: section 2 is Background and related work, while 3 deals with vehicular communication and in 4 we talked about system model, 5 is Result and discussion and conclude in section 6 .

II. BACKGORUND AND RELATED WORK

Power control is vital because it is a means of balancing received power levels or balancing or guaranteeing signal-to -interference ratios (SIRs) [24]. It aims to minimize energy consumption subject to maintaining a transmission rate. Some power control schemes have been implemented in literatures, open and close-loop power controls which main focus has been on capacity and control issues [9]. The former is designed to solve the near-far problem. The essence of open-loop power control is to ensure that the power received by all users are equal in average at the base station, while the close loop is design for reducing the

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effect of Rayleigh fading [10, 39-40]. In our simulation, we have implemented power control with the combination of rate algorithm and propagation processes.

We proposed a centralized power control scheme for mobile communication systems with shadowing and fast Rayleigh fading. The essence of power control is to minimize the total transmit power with constrains on outage probability for each user on network and with constrains on individual transmit and received signal powers [39]. Here we considered a transmitter sending data via an access point (AP) and via a communication channel subject to time-varying interference. As the vehicles changes speed and locations, there are interferences such as tall building and trees which interferes with the received signal power. Since our goal is to ensure quality of services (QOS) inform of information transmission rate or average delay while conserving energy, we have implemented a power control scheme with fast fading so that energy distribution and conservation will be achieved by all vehicles. In addition to our robust algorithm, this paper focuses on the performance of power control on existing and our proposed rate algorithm.

III. VEHICULAR COMNUNICATION

Vehicular communication can either be a Ad-Hoc network where all vehicles communicates with each other directly or infrastructure network where vehicles communicate via an AP as shown in . The following conditions are applicable:

- ❖ Vehicles routinely broadcast their position, velocity, and acceleration using built-in DSRC communication system
- ❖ With the knowledge of nearby vehicle's status, the on board DSRC alerts the driver of impending threats

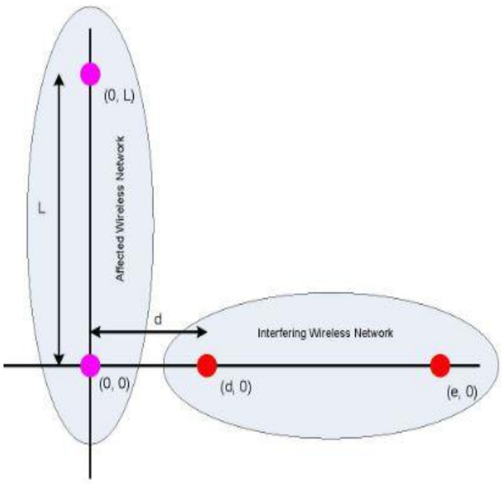

Figure 1. Geometry of the Network.

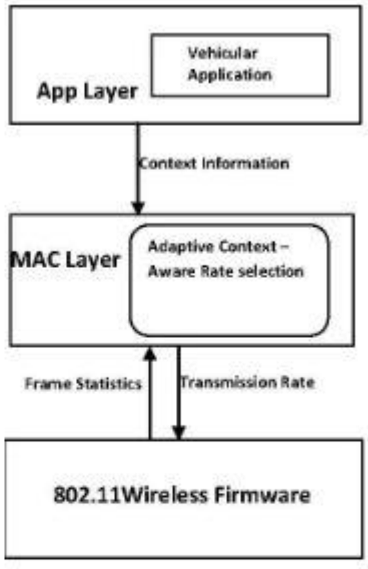

Figure 2. Overall structure of ACARS.

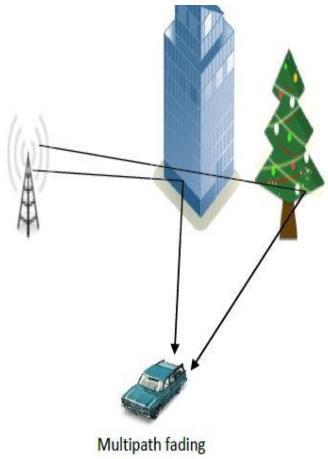

Figure 3. Channel Modelling in Wireless Mobile Networks.

A. Free space Path loss

Free space Path loss model is a power off that is relative to distance. Due to high mobility of vehicles as speed changes, the distance between the transmitter and receiver changes, this makes empirical free space path loss necessary in order to model the effect of distance on packet delivery probability. This space loss accounts for the loss due to spreading of radio frequency (RF) energy as transmission of signals propagates through free space From the equation of path loss, it is seen that the power density is reduced by $1/R^2$ as distance is increased.

$$g_p(t)\,(\mathrm{dB}) = 10\log10(16\pi^2 d\alpha^2/\lambda^\alpha) \quad (1)$$

$$P_{tx} = 10*\log10(power*10^{-3}) \quad (2)$$

$$P_{rx} = P_{tx}(\lambda_0/4\pi R)^2 \quad (3)$$

Where λ is wavelength in meters, d is distance in meters, gp(t) is empirical path loss, P_{rx} is received power, P_{tx} is transmit power, P_{noise} is noise power, power is normalized transmit power, α is alpha and $g_s(t)$ is the shadowing effect that was added to the received signal.

Also, $P_{tx}(\lambda_0/4\pi R^2)$ is the power density and power is the normalized transmit power shown in Table I. In free space , the power of electromagnetic radiation varies inversely with the square of distance, making distance an ideal indicator of signal level as well as loss rate. Due to imperfect propagation environment, in practice it is not exactly the inverse square. Distance between sender and receiver gives a high correlation between signal level and error rate as this affects the number of transmitted packets that will be received [16].

B. Impact of Power Control on Context Information

The level of power reception affects the quality or level of signal for transmitted packets. It is similar to the effect that distance has on the quality of signal to be received due to path loss effects as vehicles moves aware or close to the AP . The path loss of a wireless link can be represented by the difference between the transmit and receive power.

$g_{(t)} = g_p(t) + g_s(t) + g_m(t)$ (4)

where $g_{(t)}$ is power gain, g_p (t) is path loss, g_s (t) is shadowing and g_m (t) is multipath fading and RSS is the received signal strength.

$P_{rx} = P_{tx} - g_{(t)}$ (5)

$RSS = P_{rx} - P_{noise}$ (6)

C. Fading and Shadowing

In wireless communication design, it is very vital to predict what type of fading that may occur and providing remedies to it if it possible. And where remedies may not be possible it is important to predict the likelihood of the outage. In order to get a more realistic received power, it is important to model or add to the system, the effect of fading and shadowing which occur as a result of the presence of obstacles and tall building that may interfere with the reception of the signal from transmitter to receiver. It is very obvious, that tall buildings and trees are the basic interferers of signals in vehicular communication; therefore it is necessary to consider them when estimating received power. Furthermore, shadowing effects is combined with path loss estimates by the addition of a zero-mean Gaussian random variable, with standard deviation **σ** which values can be chosen between 6 and 12dB.
The shadowing effect is described as log-normalized distribution as seen in equation 4.

IV. SYSTEM MODEL

In this paper, simulations were performed in the following areas: Mobility of vehicles in existing and proposed rate adaptation algorithm, power gain, evaluation of multipath fading on rate algorithms, power control with AP coordination for rate algorithms in vehicular network.

A. Mobility Model and Vehicular Communication

In this scenario, all vehicles acts as clients while the RSU is acts as the receiver. Vehicles generates their positions randomly, while distance between vehicles and AP was calculated from equation 18. Our set up consists of a road length of 100m with a communication range of 300m. Other parameters for this scenario are shown in Table I.
All vehicles starts at the same time at the beginning of the road, and establishes connection once in range with the server (AP) which is located at the middle of the road, and also called Road side unit (RSU) vehicles selects speed uniformly over this range to ensure that all vehicles are within **0** and **x_max** (length of high way), a modular function was adopted in this implementation.

$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2 + \cdots + (x_n - y_n)^2}$ (7)

where d is the distance between vehicle and AP, x and y are two co-ordinate positions of the vehicles.

$[\,Speed_{avg}*0.75,\ Speed_{avg}*1.25]$Km/h (8)

We have used same (Speed_avg) as in [2][17] which is 55Km/h, and simulated for different number of vehicles. We also calculated the distance between vehicles and AP by using the distance equation between two points, so that number of vehicles in communication range can be determined. Parameters used in this simulation are listed in Table I.
This algorithm is robust to wireless and mobile environment as it is able to over the challenges of short duration, fast change in link condition and underutilization of link capacity which affects other schemes from selecting the optimum data range.
By using the optimum higher data rate , ACARS is able to reduce network load and congestion as some vehicles depart from communication range, thereby improving the throughput of the network.

TABLE 1. CONFIGURATION PARAMETERS

Parameters (Units)	**Values**
Length of Road (m)	1000
Number of vehilces	150
Position of AP (m)	500
PHY and MAC Protocol	802.11p
Frequency (GHz)	5.89
Normalized Transmit Power (mW)	40
Noise Power (dBm)	-90 [4]
α	2.0
α (dB)	8 (6.309573445) in decimal
Communication Range	2.0
	300m

TABLE II. PATH LOSS EXPONENTS FOR DIFFERENT ENVIRONMENTS [15]

Parameters (Units)	**Values**
DIFS (μs)	50
SIFS ((μs)	30
HPHY (bits)	192
HMAC (bits)	200
Data rate (Mbps)	3, 4.5, 6,9,12,24,27
Maximum Retransmission	3

Environment	**Path Loss Exponent (n)**
Free space	2
Urban area cellular radio	2.7 - 3.5
Shadowed urban cellular radio	3 -5
In building line-of sight	1.6 - 1.8
Obstructed in buildings	4 -6
Obstructed in factories	2 - 3

B. Overview of Algorithm

We have implemented our power control scheme based on adaptive rate algorithm and propagation process using different Path loss exponents as shown in Table II. This algorithm uses context information to estimate packet delivery probability. The vehicles make use of information available from each vehicle from the application layer and then the MAC layer handles the rate selection . This algorithm calculates transmit power in order to estimate SNR from PHY layer and then it determines the various metric parameters shown in Figures 6-12.

Algorithm 1 Power Control Algorithm

Function :ACARS$_{\textbf{Power Control}}$
Input : ctx, , len,snr
Output: ACARS$_{\text{Metric}}$, Parameters
1: Requires : Position of Vehicles
2: Requires : Speed of Vehicles
3: Check : if Vehicle(s) is in Communication Range
4: Initialize : the Positions of the Vehicles
5: Determine : new Positions of the Vehicles from equation(7)
6: Determine : the distance of the Vehicles from Equation (3)
7: Determine : the Vehicle(s) in Communication Range from equation
8: Requires : mobmodel(t; v; oldpos; ap;CommRange; n; xmax) for Context information
9**: if** Thr > MaxThr then
10:BestRate < bitrate
11: MaxThr < Thr
11 :Update: Power Gain Vehicles
12: Return: Throughput of Vehicles
13:Return : Metric Parameter
14: ENDIF

V. RESULT AND DISCUSSION

We have simulated using MATLAB and from figures 7- 9, it shows how path loss exponent affects the network performance and capacity. One of the importance of PC is to increase network capacity. From the result shown in these figures, ACARS out-performed existing rate algorithms, this is because it can estimate SNR from the PHY layer . As shown in Table II, in free space, **n** is equal to 2, and in the presence of obstructions, the value of **n** will be larger. The value of **n** depends on the environment.

We simulated for values of **n** between **2** and **4** to evaluate the impact of propagation processes on different environment. The values used for this simulation corresponds to the different environments listed in Table II.

From these figures, it is clear that propagation processes affects the output of various rate algorithms but ACARS *could* still achieve about 1.8Mbps for a congested network of about 150 vehicles. From Table III of [2], they achieved a throughput of 5.689Mbps for 150 nodes without fading processes , in [2], they achieved a throughput of 5.0Mbps for 50 nodes with fading, while from [18], CARS achieved a throughput of 8.33Mbps for 50 with fading and we achieved [18] a throughput of 5.89Mbps for same condition. From these analyses, we can see the much effect of fading processes on CARS and the drop in network performance in the presence of propagation processes. Our proposed performs better by adapting to channel conditions and propagation processes compared to other rate algorithms.

Figures 10-12 shows interesting result where ACARS, have a low energy efficiency compared to the other algorithms . From the plots, it also shows that path loss exponents affect the performance of the network, as shown from the figures, as path loss exponent increases, the performance metrics of the networks decrease, one of the reasons is because , as network channels varies from free space to obstruction of buildings as shown in Table II, interference to the transmit signal increases as a result of environmental factors. Presence of tall buildings and trees affects the power gain and hence affects the performance of the network.

ACARS as shown, survived these interferences and propagation effects and can utilize energy consumption for communicating vehicles at varying speeds and ensures power distribution and management for each transmitting vehicle thereby minimizing the energy consumption for vehicles from the updating of power gain as shown in equations 12-14.

From figures 11-13, results shows that CARS has a low PER rate for path loss exponents of **3** and **4** respectively but do not for free space . PER is an indicator of how the system throughput, because if PER increases, throughput will decrease. The reason why ACARS did not follow same trend as for values of **α** when **3** and **4** has not been investigated for, this will be one of our future works.

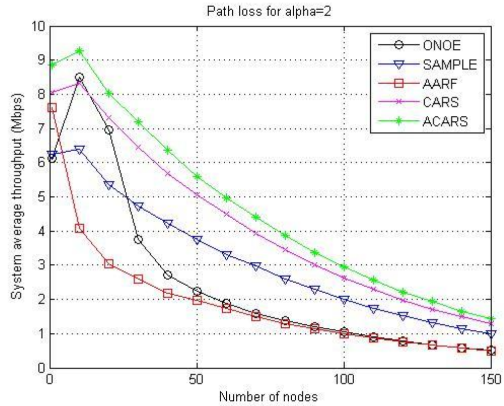

Figure 4. Impact of Path Loss on System Throughput for alpha = 2

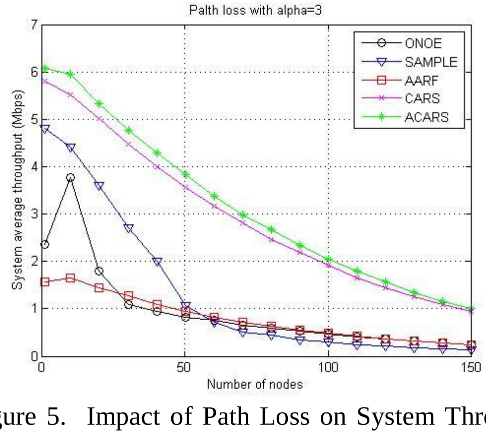

Figure 5. Impact of Path Loss on System Throughput for alpha = 3.

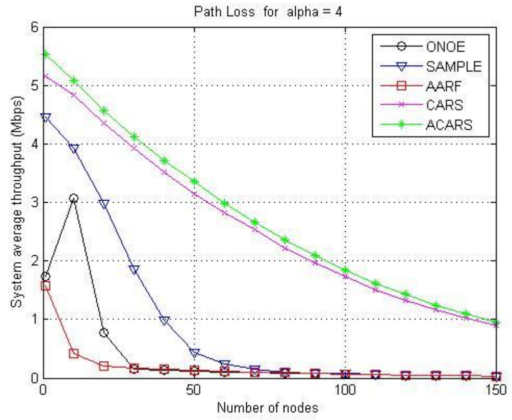

Figure 6. Impact of Path Loss on System Throughput for alpha = 4.

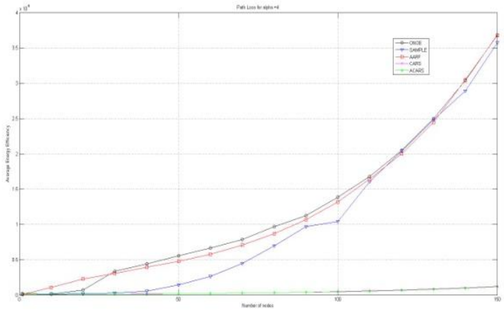

Figure 7. Impact of Path Loss on Energy Efficiency for alpha = 2.

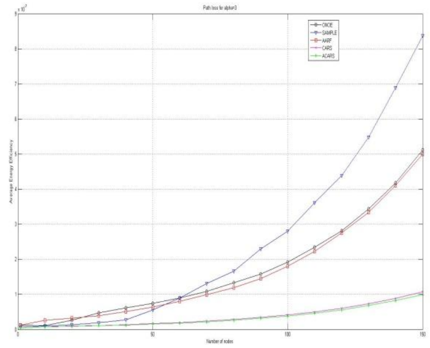

Figure 8. Impact of Path Loss on Energy Efficiency for alpha = 3.

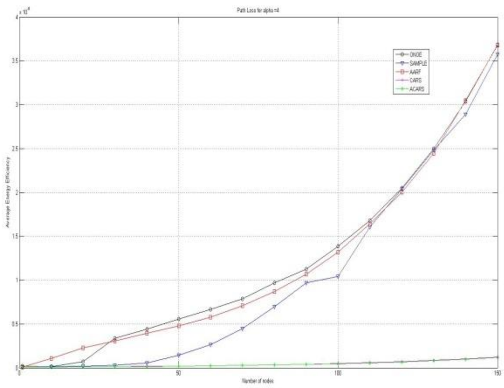

Figure 9.Impact of Path Loss on Energy Efficiency for alpha = 4.

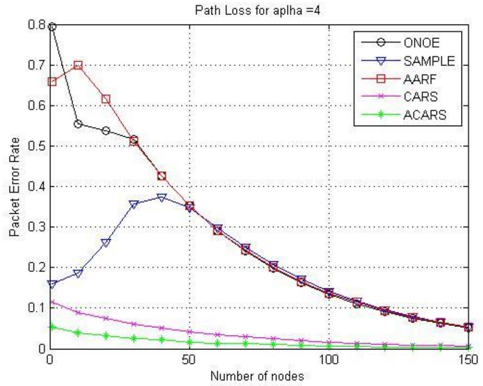

Figure 10. Impact of Path Loss on PER for alpha = 2.

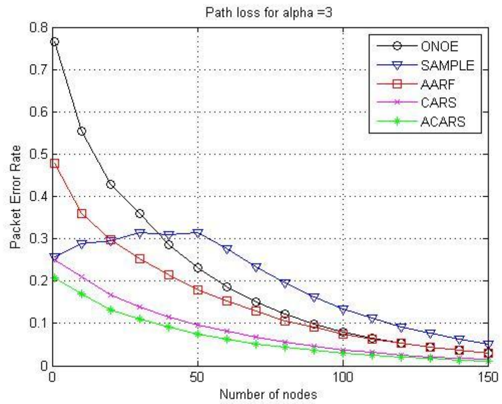

Figure 11. Impact of Path Loss on PER for alpha = 3.

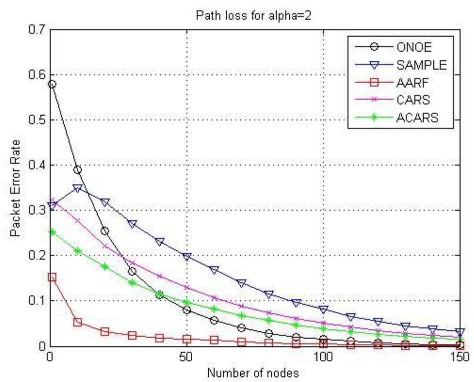

Figure 12. Impact of Path Loss on PER for alpha = 4.

A. Doppler Effect

Doppler effect is the corresponding changes in frequency produced as a result of moving object at significant speeds. It is usually heard when an emergency vehicle passes an Observer at a high speed. We have neglected the effect of Doppler shift by assuming that frequency demodulation is perfect . We have also neglected path delay by assuming that channel frequency is also perfect [21].

VI. CONCLUSION

In this paper, we have investigated on existing rate adaptation algorithms and their underutilization of wireless link capacity in vehicular environments, by introducing an adaptive context aware rate selection (ACARS) algorithm that adapts to wireless and mobile channels and performs better than the others in the presence of propagation processes.ACARS performs well because it can estimate SNR from the PHY Layer to be used in combating propagation processes, while the others cannot because of this reason.

Our simulation also shows that ACARS can minimize power consumption for vehicles using its robust ability among existing rate algorithms by the integration of power gain into the rate algorithm. Other very importances of power control in this simulation are:

- to reduce network congestion
- improve quality of service
- collision avoidance
- road safety application

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