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Path Loss Analysis Considering Doppler Shift Effect on Cellular Communication for Connected Car Application at Rural Area

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Abstract. In this paper, the study on the loss of pathways in cellular communication is carried out by experimentation and simulation on three different modules in rural areas. These three-communication module has different carrier frequencies to determine the effect of the doppler shift to the loss of the moving vehicle communication path. The simulation and experimental output are compared to improve the accuracy of these studies. Simulation studies are based on the proposed model for the modified path loss. For the experimental portion, the path loss was determined based on two things: the measured received power on communication modules antenna and transmit power from base station. From this study, the best selection of the communication module is selected for use in connected cars by considering the fading effect of doppler shift.

1. Introduction

Nowdays vehicle technology has grown rapidly, this is including information systems that can improve the capability of analysis on vehicle condition [1-10]. Basic information like the location of the car and the performance of the motor vehicle itself can be monitored. Vehicles nowadays have employed several Engine Control Unit(ECU), from just one in the last few decade, to enable them to share information with one anaother [11]. In the 1990s, with the introduction of 802.11 wireless communication standard, ECU is no longer limited to internal communication within the vehicle system, but can also share information between different vehicles [12]. This technology has enabled the connected car system to support ITS(Intelligence Transport System).

According to Kleberger et al, the connected car consists of three domains: the vehicle itself, which consists of the in vehicle network and the ECUs, the automotive company's portal and the communication link between them [13]. This paper focuses on the communication link between the vehicle and the database to ensure the reliability of information sharing on cellular networks. As Junyeong et al. suggested, improving the quality of communication link is important as vehicle speed and data packet size increases [14].

2. Existing Studies

There are few solutions proposed to improve the quality of communication. Jyothi et al has recommended the use Global Communication System Mobile (GSM) SIM900A for advancing mobile communication, instead of Blueetooth and Zigbee system. Two main parameters must be analyzed before the communication module is implemented on the connected car: path loss and doppler shift effect [15]. Although there are many models available to analyze the path loss model, not all of them can be used in certain unique environments[16]. Studies have also been carried out on the loss of track between transmitter and receiver in urban and suburban environments [17]. Significantly, there are only a few studies that consider the influence of the doppler effect in the loss of the pathway.

3. Communication Node Development

Communication node hardware has been developed with three devices that are Arduino Uno, GSM modem and GPS. For GSM, three different models (with separate band and coverage) have been selected to test their communication performance; SIM900, SIM800L and SIM5360E. Note that SIM900 and SIM800L are using 2G signal for their communication coverage. In this experiment, SIM900 was using 1800MHz as the system band. Alternatively, for SIM800L and 900MHz, they were set as network band by using the AT+CBAND AT command. Lastly, SIM5360E was set to using UMTS 2100MHz as network band due to the modem 3G coverage capability. The experiment setup for these three GSM modems can be referred in Figure 1. Each communication node will perform the AT+CSQ AT command to obtain the communication modem Received Signal Strength Indicator (RSSI) which determines the received power in the GSM Antenna and perform ping request to test the latency of communication link. In this communication node GPS GY-NEO6MV2 has been used to get a latitude and longitude of the vehicle in deciding the distance between vehicle location and base station. At the end, all the data from these three modules was sent to webserver at www.000webhost.com.

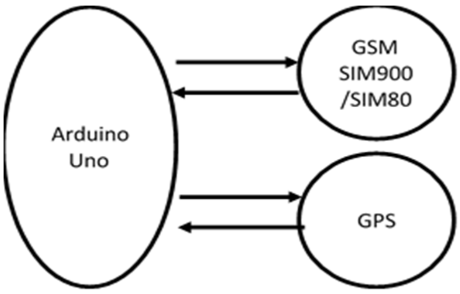

Figure 1. SIM900 Communication node

4. Analysis on measure and simulation path loss of communication that correlate to distance and vehicle speed

For communication link performance analysis, the experiment used only one method; measure track loss based on RSSI data in each communication module type. This communication module has been tested by moving the vehicle around the countryside as shown in Figure 2. During this test, three different speeds were used: 60 km/h, 90 km/h and 120 km/h.

Figure 2. Jalan Pauh-Jitra rural area beside paddy field road

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The distance between vehicle and base station along the road was determined by referring to the Open Signal App.

Next, this doppler shift parameter was employed in calculating path loss in Tuned Free-Space path model using the following formula[19]:

$$L = K_1 \times log_{10}(f_d) + K_2 \times log_{10}(d) + K_3 + 32.45 + 20 \times log_{10}(d) + 20log_{10}(f) \quad (1)$$

Where L is a path loss result that obtain from Tuned Free-Space model by using K_1, $K_2$and K_3 that is median of optimum values minimum error between tuned path loss model and measured data obtained from Hong et al. analysis result on signal measurement at rural area. The value of K_1=5.0, K_2=19.2 and K_3=9.0.corrosion.

5. Results

Based on the 3rd Generation Partnership Project (3GPP) in Technical Specification Group Radio Access Network, Evolved Universal Terrestrial Radio Access (E-UTRA) and Base Station (BS) radio transmission and reception (Release 15) that state, the standard transmitting power for macro cellular communication base station is 46dBm. The result in Figure 3, where track loss data are generated based on RSSI measurement from the communication module and power transmission from the base station. The difference in the loss of the path in the communication link are shown to increase with the increase of frequency.

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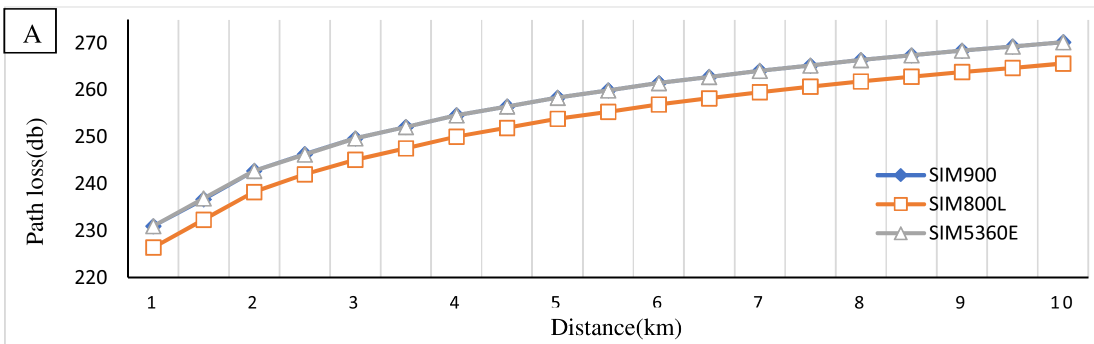

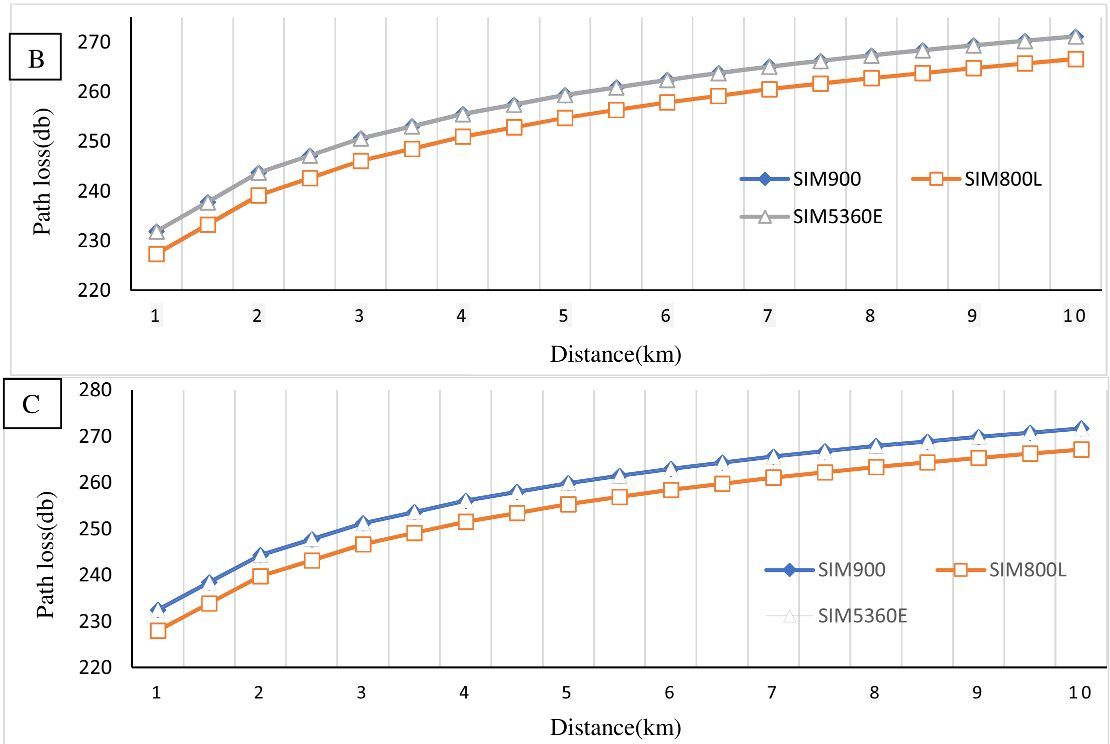

Figure 3. Path Loss vs Distance Tuned Free-Space path loss model data for three different communication modules (A=60km/h, B=90km/h and C=120km/h)

6. Conclusions

In this paper, the effect of the propagation path loss on the connected car communication link was investigated taking into account the doppler effect. The results of the experiment showed that SIM800 is the most suitable due to the low frequency of the communication module. This shows that the lower the frequency band, the better signal propagation link. However, further research is necessary to improve the understanding of the communication link in urban or suburban areas before any conclusions can be reached. Data from this study can therefore be applied to network technologies that specialize in connected automotive communication systems with another component, such as signal encoding algorithms and network technologies.

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References

[1] Hamid A F A *et al* 2017 *J. Phys. Conf. Ser.* **908** 12079.
[2] Norizan A *et al* 2017 *J. Phys. Conf. Ser.* **1** 12069.
[3] Mohamad M L A *et al* 2017 *J. Phys. Conf. Ser.* **908** 12042.
[4] Azmeer M *et al* 2017 *J. Phys. Conf. Ser.* **908** 12051.
[5] Zaidie M N A *et al* 2017 *J. Phys. Conf. Ser.* **908** 12058.
[6] Zaman Z I *et al* 2017 *AIP Conf. Proc.* **1885** 1.
[7] Rahman A *et al* 2018 *IOP Conf. Ser. Mater. Sci. Eng.* **429** 012049.

[8] Aziz S *et al* 2018 *IOP Conf. Ser. Mater. Sci. Eng.* **429** 012075
[9] Manaf E H A *et al* 2018 *IOP Conf. Ser. Mater. Sci. Eng.* **429** 012048.
[10] Manaf E H A *et al* 2018 *AIP Conference Proceedings* **2030** 020115.
[11] Prashant A *et al* 2015 *International Conference on Circuit, Power and Computing Technologies* 7.
[12] Coppola R *et al* 2016 *ACM Comput. Surv.* **49** 46.
[13] Kleberger P *et al* 2011 *IEEE Intell. Veh. Symp. (IV)* 528.
[14] Bok J *et al* 2014 *Int. Conf. Adv. Commun. Technol.* 1.
[15] Phillips C *et al* 2013 *IEEE Commun Surv Tutorials. V* **15** 255**.**
[16] Alam N *et al* 2010 *IEEE Veh. Technol. Conf.* 1.
[17] Amornthipparat A *et al* 2008 *Second International Conf. ICCE.* 336.
[18] Wei H *et al* 2010 *5th Int. Commun. Netw. China ICST Conf.* 1.