MILLIMETER WAVE FOR VEHICULAR COMMUNICATION USING EFFICIENT CODING TECHNIQUE

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ABSTRACT

A promising technology for vehicular ad-Hoc Networks (VANETs) is Millimeter-wave (mmWave). mmWave is, however, susceptible to path loss and fading, which degrades system performance. Error-free data between Vehicle to Vehicle (V2V) and Vehicle to Infrastructure (V2I) in the context of fading and mobility of vehicles calls for in-depth research.

In addition to the above-mentioned limitations, challenging issues degrading the reliability of VANET are the problems of high penetration loss and blocking. To establish effective communication in mmWave networks in context of vehicles, a detailed understanding of the VANET communication channel is necessary, which differs significantly from those explored at frequencies lower than 6 GHz. When a vehicle's speed exceeds 50 km/h, Doppler shifts can have adverse affects on the reliability of V2V communication. The transmission becomes impossible in VANET because of the increasing mobility of the nodes.

This research presents three tractable channel models for VANET in which system performance degradation due to error is addressed. The operating frequency is 60 GHz. In the first model, concatenated Bose–Chaudhuri–Hocquenghem (BCH) and Alamouti Space-Time Block Coding (ASTBC) and coding are used. The two Bit Error Rate (BER) closed-form approximations, one for BCH in Rayleigh fading and the other for BCH with ASTBC, are obtained. Signal to Noise Ratio (SNR) and code rate are included in these expressions, which can be used to create VANET systems. The findings demonstrate that the BER obtained by concatenating ASTBC and

BCH is 10^{-5} thus outperforming the traditional BER obtained by ASTBC expression. The code rate (127,36), (127,64) and (255,251) are used to evaluate the performance of the proposed expressions.

The second model is designing a comprehensive tractable model for VANET over millimeter waves that combines Reed Solomon (RS) coding with Space-Time Block Coding (STBC). The closed-form approximations for BER of RS in the Additive White Gaussian Noise (AWGN) channel and Rayleigh fading are derived. The performance of RS closed-form expressions is compared with previous BER computation approaches. The results shows that the BER lies between 10^{-7} to 10^{-6}. Furthermore, the model's performance has been compared with the current VANET communication systems, specifically the IEEE 802.11bd and 3GPP V2X communication systems. Results are comparable with V2X NR and demonstrate that our suggested approach works better than IEEE 802.11bd. As metrics for performance, throughput, Packet Error Rate (PER) and Packet Reception Ratio (PRR) are employed. The model has also been evaluated with vehicles moving at faster velocities. Further, the simulation and numerical findings show that the AWGN approximation for STBC-RS model outperforms Reed Solomon - Mary Phase Shift Keying (RS-MPSK) traditional system i.e. the achieving the BER of 10^{-7}. These derived expressions can be adopted in designing various VANET architectures targeting reliability in the network. The path loss and fading are reduced since the directivity of the transmitter has increased using beamforming.

The analytical and numerical results are compared, demonstrating the accuracy of our closed-form expressions. In the third model, the impact of the Doppler shift using BCH and RS coding is also analyzed in VANET communication. Since Orthogonal Frequency Division Multiplexing (OFDM), which is highly susceptible to Doppler shift, is used by the IEEE 802.11p PHY layer. It is seen that the results of the suggested model surpass those of earlier models, including 802.11p.

Considering there exhibits a strong dependence of 5G/6G communication on both the molecular composition of the medium and the transmission distance. The closed-form expressions of BER are simulated in the Terahertz (THz) channel. A detailed analysis of relative humidity dependency on code rate is conducted. Further, the relation between code rate and relative humidity is analyzed. The results are analyzed at different code rates. Moreover, we have compared our results with the performance of existing ASTBC technique in the THz channel. The results depict that the proposed model surpasses the behavior of the ASTBC equation in THz. The findings presented here are expected to pave the way for ultra-reliable vehicular communication networks.

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List of Abbreviations

ALOHA	Advocates of Linux Open-source Hawaii Association
AP	Access Point
ARQ	Automatic Repeat request
BI	Beacon Intervals
BSS	Basic Service Set
CAM	Cooperative Awareness Messages
CALM	Communication Access for Land Mobile (CALM)
C-ITS	Cooperative Intelligent Transportation Systems
CRC	Cyclic Redundancy Check
CSMA/CA	Carrier-Sense Multiple Access with Collision Avoidance
DCF	Distribution Coordination Function
DMG	Directional Multi-Gigabit
DENM	Decentralised Environmental Notification Messages
ECC	Error Correction Code
EDGE	Enhanced Data Rates for GSM Evolution
EGPRS	Enhanced GPRS

EIRP	Average Equivalent Isotropic Radiated Power
ETCS	Electronic Toll Collection Systems ETCS
FCC	Federal Communications Commission
FSO	Free Space Optical
FST	Fast Session Transfer
GPRS	General Packet Radio Service
GSRRS	Global Status Report on Road Safety
ISO	International Standardization Organization
ITS	Intelligent Transport Systems
LSTM	Long-Short Term Memory
LDPC	Low Density Parity Check
LRR	Long Range Radar
LTE	Long Term Evolution
MDS	Maximum Distance Separable
MMSE	Minimum Mean Squared Error
mmWave	Millimeter Wave
MPSK	M-ary Phase Shift Key-ing (MPSK)
MQAM	M-ary Quadrature Amplitude Modulation
NGV	Next-Generation V2X
NSCC	Non-Systematic Convolutional Codes (NSCC)

PCP	Personal Basic Service Set Control Point
PRF	Prime Reliability Factor
R	Correlation Coefficient
RMSE	Root Mean Square Error
RS	Reed Solomon
RSU	Road-Side Unit
sRLNC	Systematic Random Linear Network Coding
SCC	Systematic Convolutional Codes
SRR	Short Range Radar
UFMC	Universal Filtered Multi-Carrier
URLLC	Ultrareliable and Low-Latency communication
UWB	Ultra Wide Band
VC-MAC	Vehicular Cooperative Media Access Control
VSC	Vehicular Safety Communication
V2V	Vehicle to Vehicle
V2I	Vehicle to Infrastructure
VITP	Vehicular Information Transfer Protocol
VTL	Virtual Traffic Light (VTL)
Wi-Fi	Wireless Fidelity
WiMax	Worldwide Interoperability for Microwave Access

WLAN	Wirelesss Local Area Netwroks
WPAN	Wireless Personal Area Networks
WHO	World Health Organization
ZF	Zero Forcing

List of Symbols

STA	IEEE 802.11 device a station
$Gbps$	Giga bits per second
Mph	Miles per hour
km/h	Kilo meter per hour
EB	Exabyte
γ	Signal-to -Noise Ratio
P_t	Transmitter power
G_{tx}	Transmitter array gain
G_{rx}	Receiver array gain
PL	Path loss
α	Path loss exponent
β	Model parameter for the different number of blockers
RH	Relative humidity
L_f	Free space path loss
L_a	Absorption loss
P_{ei}	Probability of error on node i

P_{BCH}	Probability of error in BCH coding
R_c	Code rate
θ	Angle of arrival
ϕ	Angle of reflection
f_d	Doppler shift
n	Number of coded bits
M	Modulation order