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Research Article

VANET Communication Range Degradation: An Experimental Study on the Ole of Interference 2.0

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ABSTRACT
In vehicle-to-vehicle (V2V) communications, the communication range degradation has been associated with high channel load. In particular, interference has been avowed to play a moderating role, suggesting that at higher distances, the likelihood of packet loss could not be overstated. It is also notable that at least two concurrent transmissions account for the packet loss, especially due to collisions that occur at receivers that come in between. The latter outcome transforms into a hidden station problem. The aim of this simulation study was to conduct a real-world experiment and discern the percentage of degradation in the communication range due to the aforementioned complexities. The study involves three radio stations, which aided in gaining data about interference and how it could cause communication range degradation. Results demonstrated that the degradation was between 50 and 70%. The number of collisions was also found to increase due to the shadowing effect of the receiving vehicle, having hidden other stations even in situations where distances were closer.
Keywords: V2V, VANET, measurement, high load, interference, field test, congestion

INTRODUCTION
The demand for active safety applications has arisen from the capacity of spontaneous communication between vehicles [1]. In situations where wireless communication technologies are equipped in vehicles, communication concerning the vehicles' movement and status is possible [2]. Cooperative Awareness Messages (CAMs) broadcast the resultant information to other nearby vehicles [3]. The eventuality is that through a local dynamic map in a given environment, all vehicles end up storing information. It is also notable that such vehicles exhibit the potentiality of checking for possible dangerous situations that include approaching ambulance vehicles and potential collisions at intersections [4, 5].
Indeed, where there is high vehicle density (such as multi-highways), CAMs' periodicity leads to communication channel overload [4]. Hence, packet losses tend to arise because of numerous collisions concerning medium access. The eventuality is that hidden station problems arise, worsening the situation by preventing or impairing the functionality of the carrier sensing. This simulation study sought to analyze the consequences and reasons for channel overload. From previous studies, there is a 90% reduction in communication ranges when the interference occurs [5]. With high load and successive packet loss, the neighbor update delay also increases significantly [3]. Therefore, the specific objective of this study lay in the comparison of the simulation outcomes with the results reported in previous scholarly investigations in the real-world. The importance of this study involved the possible ability to lay a foundation for establishing some of the countermeasures through which packet loss could be curbed.

METHODOLOGY
The designed simulation scenario involved different special aspects of communication regarding V2V operations. For the experimental setup implementation, three vehicles were selected. Both software and hardware were incorporated into each vehicle. The wireless safety unit (WSU) was selected as the basic component of the communication unit. Using a 3m long antenna cable, there was the connection of an antenna to the respective WSUs. The location of these antennas was the center of each car's roof. Relative to the parameter of positioning, a Garmin GPS18-LCV receiver was used to connect to the individual WSUs. On the logging aspect, the WSU Test Application was used to allow users in testing the MAC protocol, as well as the communication channel's performance. Lastly, the vehicles that were used entailed interfere and transmitter vehicles, which

were compact and constituted round roof curvature. In relation to the receiver vehicle, the experiment was designed in such a way that this vehicle had a flat roof and came in the form of a big off-road vehicle.

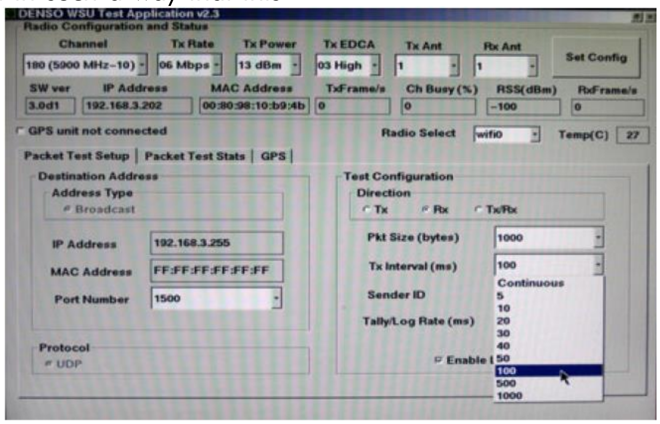

Figure 1: An illustration of packet test parameters and radio configuration for WTA

Table 1: Measurement parameters for the simulation study

Fixed Parameter	Value
Number of vehicles	3
Channel	180 (5900 GHz)
Receiver diversity	Off
Transmit power (Transmitter/Interferer)	18/12 dBm
Maximum communication range	≈ 1000 m
Data rate	6 MBit/s
Packet length (payload)	1000 Bytes
Packet rate (Transmitter / Interferer)	10 Hz / Continuous
Measurement length	5 seconds
Number of runs	2
Antenna gain - Nippon Antenna (0°/15°)	0/5 dBi
Antenna gain - Mobile Mark	9 dBi
Varied Parameters	**Values**
Interferer enabled	true, false
Distance *R-I*	1000 m, 650 m, 350 m
Distance *T-R*	900, 850, …, 50 m

RESULTS AND DISCUSSION

Initially, the results were obtained and presented for the respective receiver locations. Later, they were harmonized and summarized before comparing the state of degradation in the communication ranges that were measured in this simulation study with those measured in the real-world scenarios.

In situations where the interferer and the receiver existed at the communication range edge relative to each other, this study indicated quite low received signal strength, especially on the part of the interferer. However, with the transmitting closing in the distance from the initial 1000 meters to about 600 meters, there was a dramatic increase in the packet per second rate. When the distance was reduced further to 500 meters, the packet receive ratio operated in the transient area. When the distance of 450 meters was investigated, the receiver received all the transmitted packets. This situation retained stability with further reductions in distance, apart from the 200-meter and 350-meter distances in which single outliers existed.

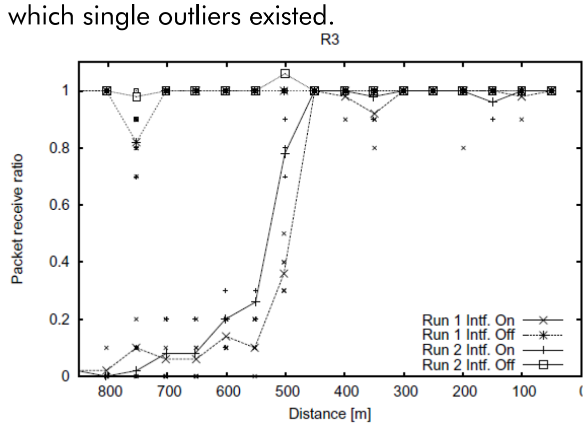

Figure 2: Trends in the packet receive ratio

The next phase constituted the measurement of the receiver-interferer distance at 650 meters. On this parameter, it is worth indicating that both the interferer and the receiver existed within the communication range relative to one another. From the specific findings, it was established that under interference, the transmitter would only be within the communication range if it moved closer to the receiver. Indeed, it was at about 700 meters that a transient area was established, with a similar outcome maintained up to about 400 meters. At 200 and 350 meters, some outliers would be observed. Given the disabled nature of the receiver diversity, some of the factors to which these experimental findings were attributed include the canceling of signals at some distances and the role of ground reflection.

The third phase of the experimental study focused on the receiver-interferer distance involving 350 meters. On this parameter, findings revealed a larger packet data loss transient area. Also, there was much fluctuation in the receive ratio and failed to reach 100%. Given that at this distance, there was a relatively high signal strength, which exceeds the first two phases whose results have been presented earlier, there was a more significant impact of the interferer. It was also at this 350-meter scenario that outliers were observed, a similar fashion as the results obtained or reported for the first two phases of the experimentation. Whereas challenges such as increased air traffic and difficult weather conditions tended to affect the experimental conditions, the results that were obtained remained valid.

In relation to the perspective of the comparison, it was evident that at the respective receiver locations, the degradation of the communication range between the receiving vehicle and the transmitting vehicle was significant. To evaluate the reliability of the results, the study proceeded to consider interactions between the interfering vehicle and the transmitting vehicle relative to the MAC protocol. On this attribute, relative to the third phase of the simulation, there was an increase in the receiver ratio at about 400 to 300 meters. For the case of the second phase, the increase of the receive ratio occurred at about 800 to 700 meters while the first phase saw this increase occur at about 650 to 550 meters.

CONCLUSION

In summary, frequent provisions of updates by neighboring vehicles determine VANETs' active safety applications. In situations where the channel load is high, there could be a significant increase in the rate of packet error, especially between the transmitter and the receiver. This study sought to examine degradations in the communication range when interference is present. Three vehicles were selected. Results revealed a degradation ranging between 50% and 70%. Also, because of own shadowing by vehicles themselves, there tends to be additional packet loss. Furthermore, significant signal attenuation causes the other transmitter to be hidden in the bigger vehicle's shadow. Due to the shadow, the eventuality is that another vehicle is unlikely to sense correctly whether or not the channel is busy.

However, even in situations where the channel load is high, there remains high communication range under interference when a range of 50 to 300 meters forms the area in which time-critical safety applications operate. In this area, therefore, there tends to be no packet-receive ratio's significant degradation. In the future, it is recommended that scholarly investigations focus on situations where multiple interfering vehicles are present and discern whether similar observations as those made in this experimental study, which relied on three vehicles, could be made. Overall, this study lays a foundation or a basic validation scenario and future investigations could extend the simulation outcomes before establishing the degree to which there might be convergence or divergence from this study's observations.

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