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Resource Allocation in C-V2X and DSRC Technologies: Analysis and Simulation-based Evaluation for V2V Direct Vehicular Communication

PROBLEM

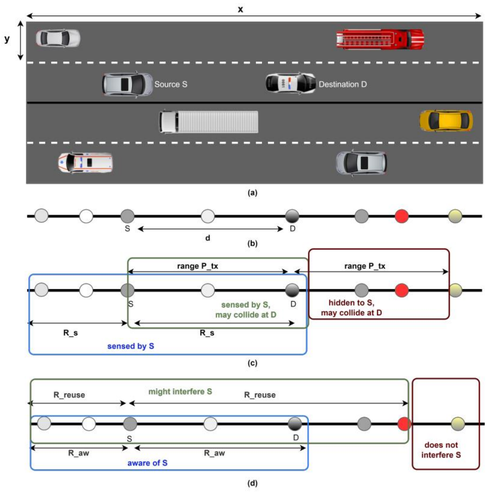
Analyze the limitations of resource allocation mechanisms in DSRC/802.11p, LTE-V2X Mode 4, and NR-V2X Mode 2 to meet the stringent demands of V2X applications in the 5.9 GHz band—considering the high topological variability arising from vehicular mobility and the lack of centralized coordination in out-of-coverage scenarios; evaluate communication reliability and effective range as vehicle density and traffic load increase; and determine whether these self-selection schemes can guarantee the optimal latency, reliability, and coverage range required for critical functions such as platooning, extended sensing, and remote driving in high-density vehicular environments.

GENERAL OBJECTIVE

Determine the effectiveness of resource allocation schemes in DSRC/802.11p, LTE-V2X Mode 4, and NR-V2X Mode 2 through a comparative analysis of reliability, packet collision rate, and effective range under varying vehicular densities, traffic loads, and transmission powers, to establish their viability for advanced V2X applications in high-mobility, out-of-coverage environments

PROPOSAL

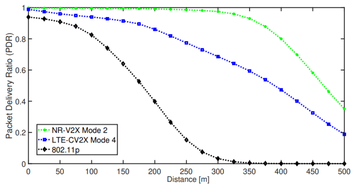
- A comparative evaluation framework combines simulations in a highway scenario using the WiLabV2Xsim simulator.
- Performance of resource allocation schemes in DSRC/802.11p (random access), LTE-V2X Mode 4, and NR-V2X Mode 2 (Sensing-based Semi-Persistent Scheduling).



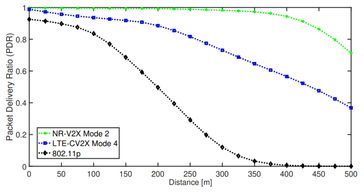
Parameter	Values
Carrier frequency	5.9 GHz
Traffic density β	0.1, 0.2, 0.3 vpm
Number of lanes	4 (y = 4 meters wide)
Highway length x	2 km
Channel bandwidth	10MHz
Transmission power P_{tx}	20, 23 dbm
Packet frequency λ	10, 20 pps
Packet size β	190 bytes
Data rate DR	6Mbps
sub-channels per sub-frame S	4
RBs per sub-channel	12(4 sub-channels)
Modulation and coding scheme	MSC 9 (QPSK 0.7)

Use case group	Transmission mode	Latency (ms)	Reliability(%)	Max. Data Rate (Mbps)	Min. Range(m)
Basic road safety (Rel-14 y 15)	Broadcast	10-100	90	31.7	100-300
Vehicles Platooning	Broadcast groupcast and unicast	10-25	90-99.99	65	80-350
Advanced driving	Broadcast	3-100	99.999	50	360-500
Extended sensor	Broadcast	3-100	90-99.999	1000	50-1000
Remote driving	Unicast	5-20	99.999	UL:25, DL:1	-

RESULTS



β=0.3 vpm, λ=10pps, Pt =20dbm



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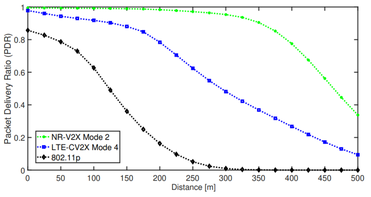
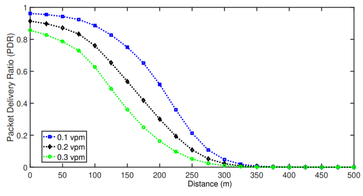
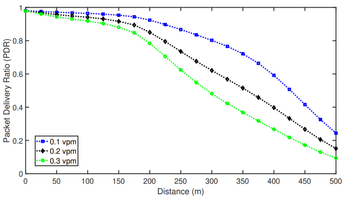
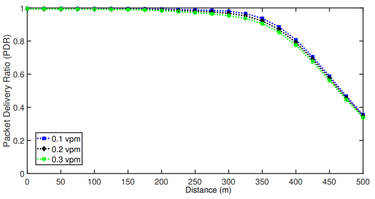


β=0.3 vpm, λ=20pps, Pt =20dbm







PDR in terms of the distance between transmitter and receiver for different traffic densities a) 802.11p, β=0.1, 0.2 and 0.3 vpm, b) LTE-V2X, β=0.1, 0.2 and 0.3 vpm, c) NRV2X, β=0.1, 0.2 and 0.3 vpm with λ=20pps and Ptx=20dbm

CONCLUSIONS

- NR-V2X Mode 2 offers the highest reliability and range, consistently outperforming LTE-V2X Mode 4 and DSRC/802.11p in Packet Delivery Ratio (PDR) under moderate vehicle densities.
- Sensing-based SPS mechanisms reduce collisions compared to random access. Still, when vehicle density exceeds 0.3 vpm and traffic load increases, the packet collision rate (PCR) rises markedly, limiting effective coverage beyond 350 m.
- From the evaluated technologies, it can be concluded that NR-V2X Mode 2 can be employed for advanced V2X service applications.