System-Level Simulator of LTE Sidelink C-V2X Communication for 5G

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15.05.2019

Outline

- Introduction
- System description
- Sidelink system-level simulator
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- Conclusion

Introduction

- Cellular-vehicle-to-everything (C-V2X) communication: a prominent service of the next generation of wireless network (5G).
- Applications: reducing traffic accidents and improving traffic efficiency.
- Quality of Service (QoS) requirements for C-V2X: ultra-high reliability and ultra-low latency.
- The system-level simulator has been implemented in order to check the performance of C-V2X communication.

System model

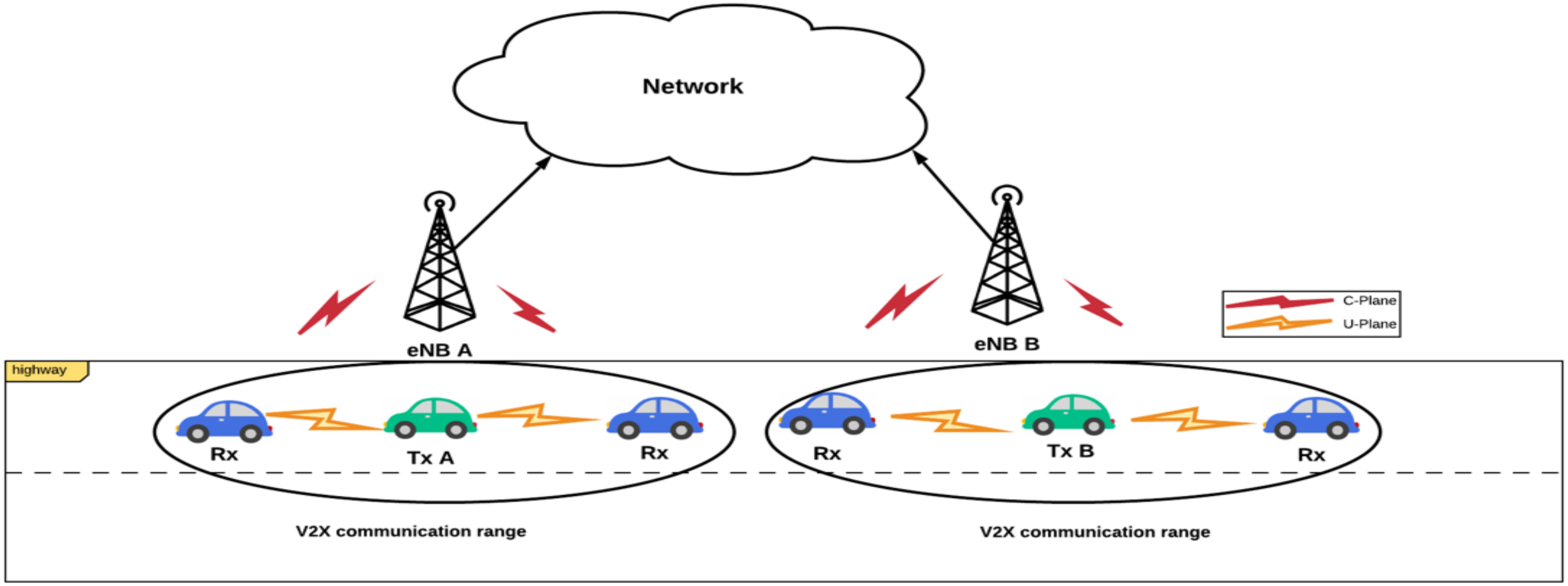


Fig.1: Direct C-V2X Communication with Network Assistance on a Highway.

- Sidelink: LTE PC5 [1]
- Sidelink transmission mode 3 [2]
- Network-assisted

Sidelink system-level simulator

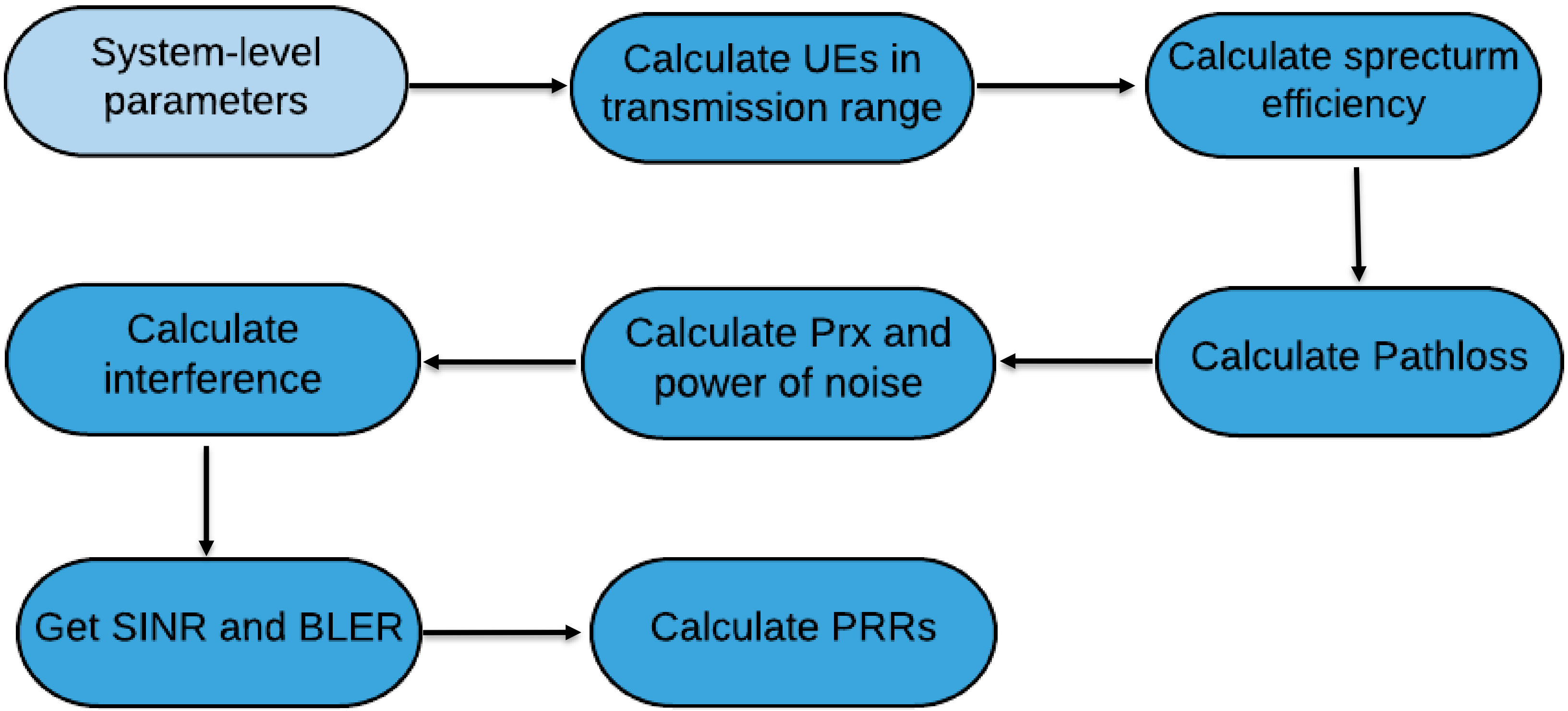


Fig. 2 System-level simulator chain

System Parameters

- Parameters

Simulation parameters	Values
Scenario	Highway
Cellular layout	ISD 1732m
Length	3000 meters
Number of Lanes	6
Lane width	4 meters
Antenna height of BS	35 meters
Antenna height of UE	1.5 meters
Channel bandwidth	10 MHz
Carrier frequency	5.9 GHz
Modulation	Unicast: adaptive MCS

System Parameters

Simulation parameters	Values
Data traffic	Highway: 10 Hz (CAM)
Packet size	256 bytes
Tx power	24 dBm
Required communication range	400 meters
Required PRR	≥ 99%
Vehicle density or IVD	54 vehicles/cell or 100 meters
Vehicle speed	100 km/h or 140 km/h
Noise figure	9 dB
Channel model	WINNER II channel model
Tx antenna gain	0 dB
Rx antenna gain	3 dB

Number of Ues and Spectrum Efficiency

- Number of UEs in the communication range.
- Spectrum Efficiency (SE)

$$dataVolume = PS \times No.UE \times Period \quad (1)$$

$$SE = dataVolume/BW \quad (2)$$

Where PS is the packet size (bytes), $No.UE$ is the number of the users. And $Period$ is the data transmission frequency (Hz).

In the second equation, BW is the system transmission frequency (Hz).

Pathloss

- Pathloss

Here taking Winner II channel model into consideration[3]

$$PL_{LOS} = 21.5log10 + 20\log 10\left(\frac{f_c}{5.0}\right), \sigma = 4, if\ 10m < d < d_{BP}, \quad (3)$$

$$PL_{LOS} = 40log10(d) + 10.5 - 18.5log10(h_{BS}) - 18.5log10(h_{MS}) + 1.5log10\left(\frac{f_c}{5.0}\right), \sigma = 6, if\ d_{BP} < d < 10\ km, \quad (4)$$

$$PL_{NLOS} = 25.1log10(d) + 55.4 - 0.13log10(h_{BS} - 25) - 0.9(h_{MS} -$$

Receiving power and noise figure

- Prx

$$P_{rx} = P_{tx} + G_{Rx\_a} + G_{Tx\_a} - PL \quad (6)$$

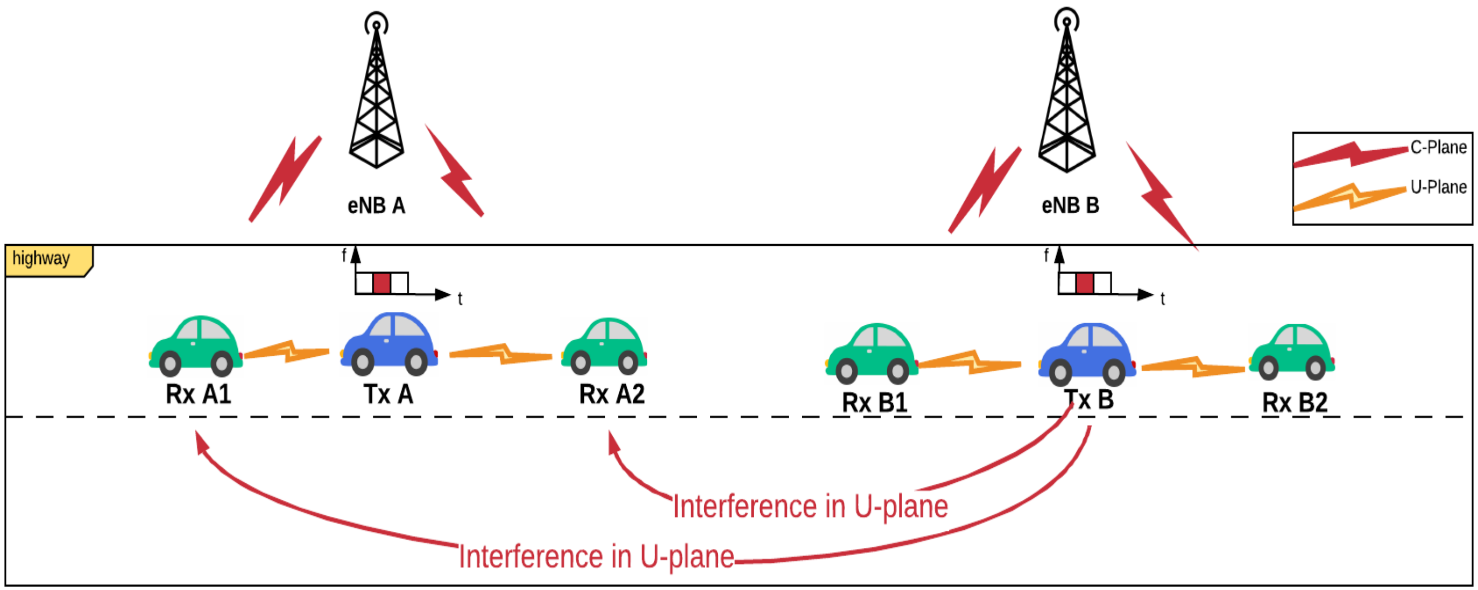
Where P_{tx} is the transmission power (dBm), G_{Rx_a} and G_{Tx_a} are the antenna gains of transmitter and receiver respectively (dBi). PL is the pathloss of the receiver (dB).

- Noise

$$Noise_P = BW + Thermal_N + Noise_F \quad (7)$$

Where BW is the bandwidth (dB), $Thermal_N$ is the thermal noise (dBm/Hz), and $Noise_F$ is the noise figure (dB).

- Interference model



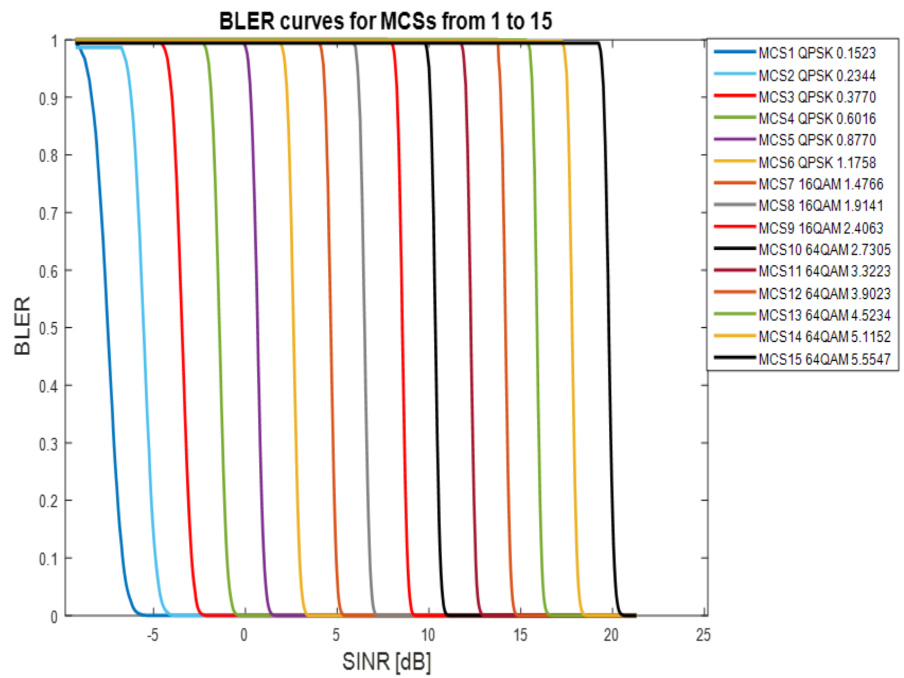
SINR and BLER

- Signal-to-Noise-plus–Interference-Ratio (SINR)

$$SINR = \frac{P_{R_x}}{P_{inter}+P_{noise}} \qquad (8)$$

Where P_{R_x} is the receiving power, and the P_{inter} and P_{noise} are the powers of the interference and noise respectively.

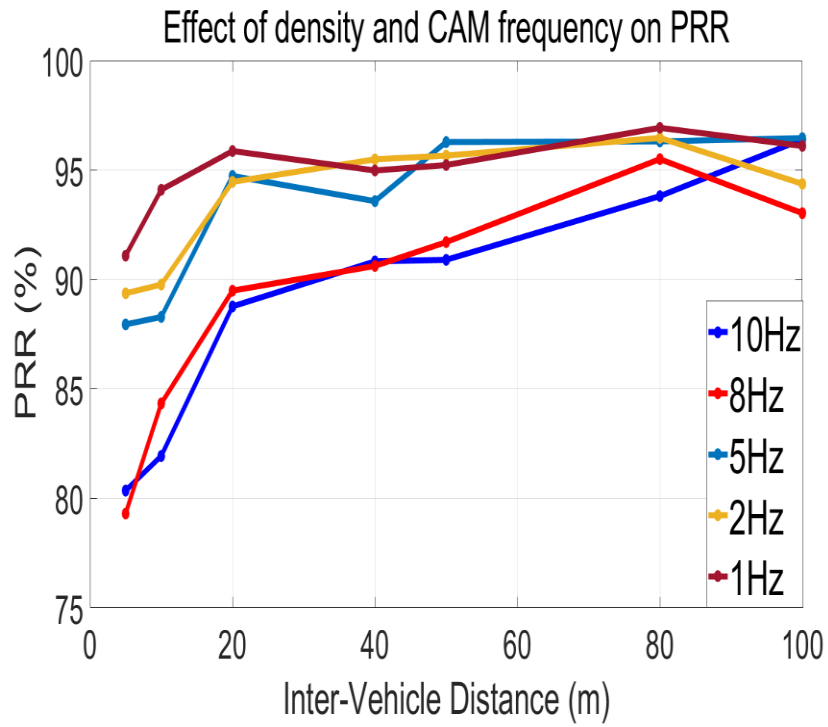
- Modulation and Coding Scheme
- Block Error Rate (BLER)



Results

- Key performance indicator
- 1% BLER threshold.
- PRRs is defined as a percentage of nodes that successfully receive a packet from the tagged node among the Rxs that are within transmission range of the Tx at the moment that the packet is sent out [5].

- Results



Conclusions

- The implementations of sidelink system-level simulator for the direct C-V2X communication on the highway scenario is clearly introduced in this work.
- We implement the whole network and get data volumes, SEs, and PRR values in order to inspect the performance of the direct C-V2X communication.
- we have provided a detailed analysis of the traffic load of this communication system. In addition, we utilize different IVDs for analyzing the influence of the communication system capability.

References

[1] 3GPP document, TS 23.303, Proximity-based services (ProSe); Stage 2, June 2017.

[2] 3GPP document, TS 36.213, Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer procedures, September 2017.

[3] IST-4-027756 WINNER II D1.1.2 V1.2 WINNER II Channel Models.

[4] LTE; Evolved Universal Terrestrial Radio Access (E-UTRA);Physical layer procedures (3GPP TS 36.213 version 12.3.0 Release 12)

[5] X. Ma, X. Chen, and H. Refai, On the broadcast packet reception rates in one-dimensional MANETs, IEEE GLOBECOM, Nov. 30-Dec. 4, New Orleans, 2008.

Thanks for your attention.