Considerations on Vehicular Channel Models

Date: 2019-01-16

Authors:

Name	Affiliations	Address	Phone	email
Paul Unterhuber, Stephan Sand	German Aerospace Center (DLR)	Münchener Straße 20, 82234 Weßling, Germany	0049-8153-28-2291 0049-8153-28-1464	paul.unterhuber@dlr.de, stephan.sand@dlr.de
Ioannis Sarris	u-blox	Athens, Greece	+30 6976080735	ioannis.sarris@u-blox.com
Malik Khan	Cohda Wireless	North Adelaide, Australia	+61 8 8361 7297	malik.khan@cohdawireless.com

Abstract

For performance evaluations of time-variant and/or location-dependent applications, use cases and scenarios average performance metrics are not sufficient, but resulting distribution including correlated events are needed.

The key to those enhanced performance evaluations are geometry-based stochastic channel models (GSCMs). These models can consider non-stationarity and spatio-temporal correlations of the environment and moving vehicles.

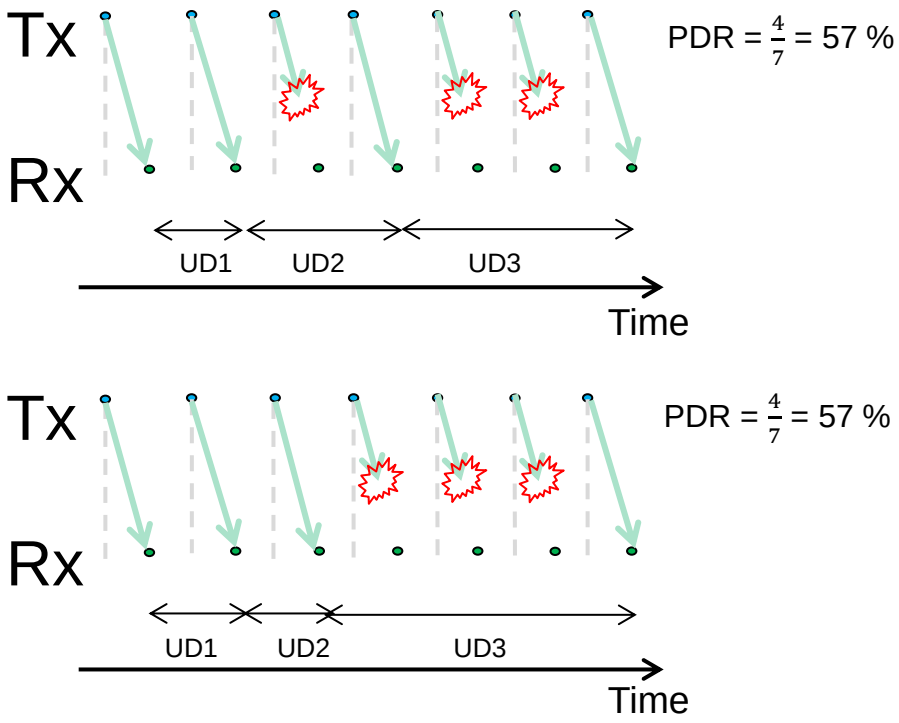
Therefore, we propose to use GSCMs.

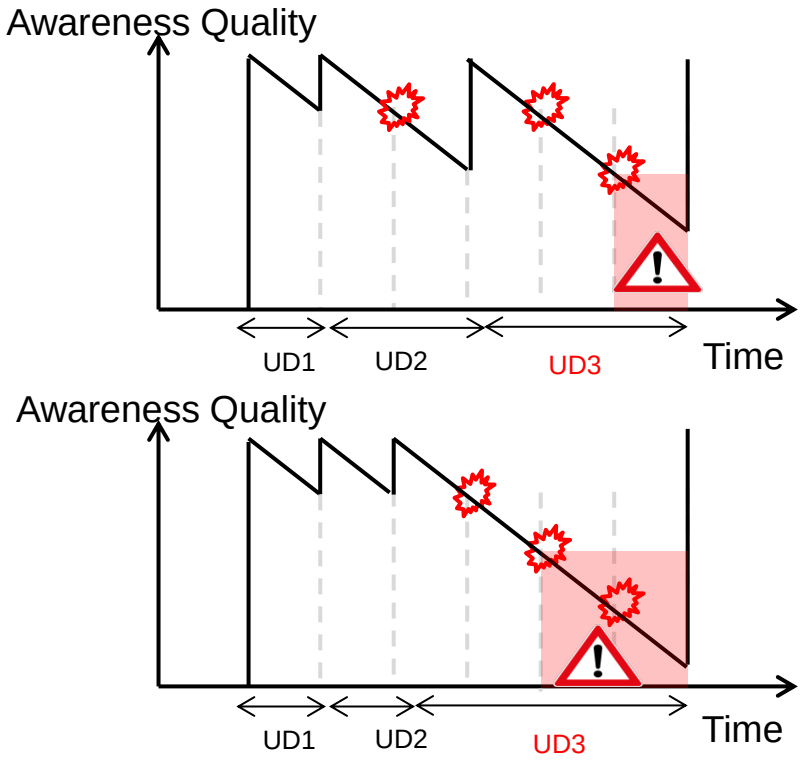
Performance Evaluation and Simulations

- **Communication Metrics**
  - Throughput
  - Delivery rates
  - Error rates
  - Latency
  - Update delay
- **Ranging and Positioning Metrics** [1]
  - Relative distance error
  - Absolute position error
  - Dilution of precision (DOP)
- **Common Measures**
  - Average
  - Root mean square error (RMSE)
  - Circular error probability (CEP) of the absolute error
  - Cumulative distribution function (CDF) of the absolute error

Update Delay (UD): Average and Distribution

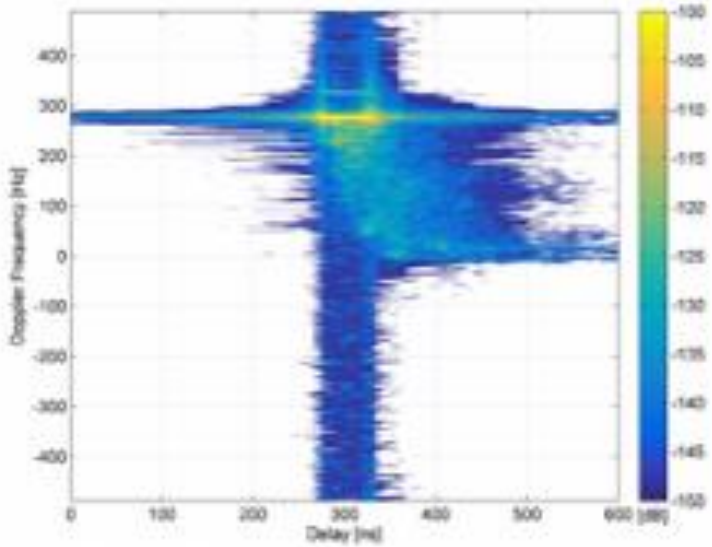
Delay between two consecutive successfully received messages

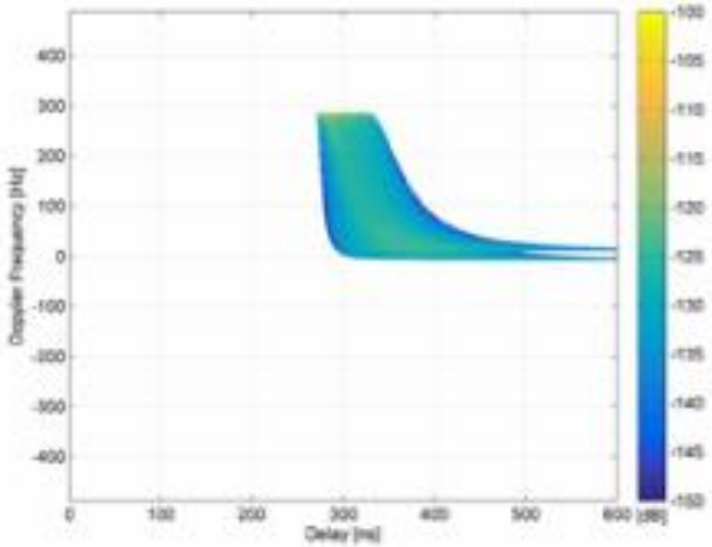




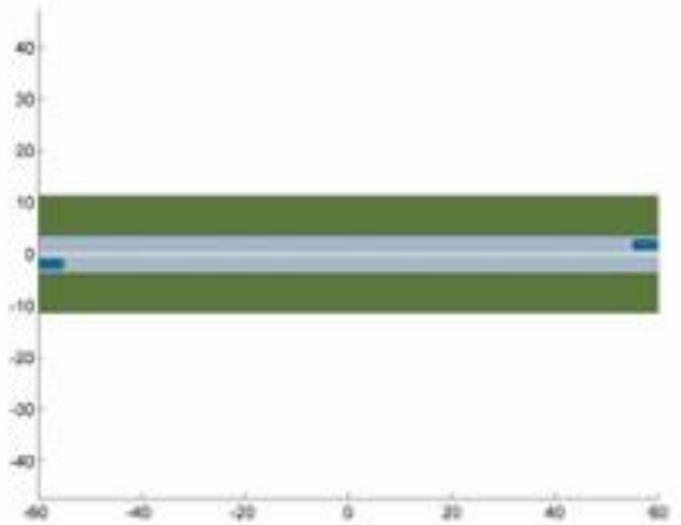
Packet delivery rate (PDR)

[2]


Doppler Frequency [Hz]
Delay [ns]
[dB]


Doppler Frequency [Hz]
Delay [ns]
[dB]


MIC OFF



[3]

Use Cases, Related Scenarios, Key Indicators

	Train-to-Train (T2T)	Vehicle-to-Train (V2T)	Sensor sharing	Vehicular position & location
Scenarios	Fast moving trains in fast changing environments	Dense and mixed urban mobility in harsh and fast changing environments	High mobility in harsh environments	Fast changing dynamics (V2P) and high mobility (V2V, V2T, A2A) in harsh environments
Applications	Exchange of safety critical information			
	Ranging			Localization
Key indicators	Uncorrelated errors, update delay			
	Detailed information of the environment			
Assumptions	**Non-wide sense stationary uncorrelated scattering (non-WSSUS)**			
	Spatio-temporal correlation [4]			

Comparison of Channel Models

Stochastic channel models

Tapped delay line (TDL)

Cluster delay line (CDL)

+ Statistical parameters
+ Low complexity
- WSSUS
- No geometry

Deterministic channel models

Ray-tracing

+ represents the physical radio propagation
+ respects the geometry of the environment
- Extremely high computational effort
- Detailed environment description necessary

Geometry-based stochastic channel models (GSCM)

+ Includes Tx, Rx or scatterer motion
+ Respects the geometry of the environment
+ Relation to physical reality
- Channel sounder measurements
- Moderate computational effort

[5, 6]

Measurements

T2T

V2V

V2T

T2T

V2P

Benefits of GSCMs

- **Temporal changing environments can be considered** [3],[7]
- **WSSUS assumption can be dropped**
- **Spatio-temporal correlation can be analyzed**
- **Widely used:**
  - 3GPP: GSCM used for system level simulations for road traffic (LTE-V2X and NR)
  - ETSI ITS-G5: GSCM used for channel models and performance analysis framework

Next steps with GSCM

- **Agreement on use cases and scenarios for GSCM**
- **Definition of parameters for GSCM**
- **Reference implementation of a GSCM in open source simulator** [8]
- **Performance evaluation of IEEE 802.11bd with GSCM**

Straw poll

Do you agree to use GSCMs in addition to TDLs in the performance evaluation of IEEE 802.11bd for applications, use cases and scenarios, where

- **WSSUS assumption is violated,**
- **spatio-temporal correlations are needed (e.g. positioning),**
- **error distributions are crucial?**

Y/N/need more information:

References

[1] S. Sand, and A. Dammann, and C. Mensing, “Positioning in Wireless Communications Systems,” John Wiley & Sons, 2014, ISBN 0470770643.

[2] I. Rashdan, et al., “Performance Evaluation of Vehicle-to-Vehicle Communication for Cooperative Collision Avoidance at Urban Intersections,” IEEE 86th Vehicular Technology Conference: VTC2017-Fall, 24-27 Sep 2017, Toronto, Canada.

[3] S. Sand, et al., “Time-variant, non-stationary Vehicle-to-Vehicle Channel Model,” https://mentor.ieee.org/802.11/dcn/18/11-18-0924-01-0ngv-time-variant-non-stationary-v2v-channel-model.pptx

[4] B. Sun, “NGV SG Use Cases,” https://mentor.ieee.org/802.11/dcn/18/11-18-1323-02-0ngv-ngv-sg-use-cases.pptx

[5] P. Almers, et al., “Survey of Channel and Radio Propagation Models for Wireless MIMO Systems,” EURASIP Journal on Wireless Communications and Networking, vol. 2007, no. 1, p. 019070, Feb 2007.

References

[6] P. Unterhuber, et al., “A survey of channel measurements and models for current and future railway communication systems,” Mob. Inf. Syst., 2016, 2016, pp. 1–14. Available at: http://www.hindawi.com/journals/misy/2016/7308604/

[7] L. Wilhelmsson, et al., “Some (Measured) Characteristics of V2V Channels,” https://mentor.ieee.org/802.11/dcn/18/11-18-1217-01-0ngv-some-measured-characteristics-of-v2v-channels.pptx

[8] I. Sarris, “V2X Simulation Model,” https://mentor.ieee.org/802.11/dcn/18/11-18-1480-01-0ngv-v2x-simulation-model.pptx