Cluster-Based Non-Stationary Vehicular Channel Model

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Abstract:

The vehicular communication channel is characterized by a time- and frequency-selective non-stationary fading process. The real-time simulation of this fading process is an unsolved scientific problem that we address in this paper. We devise a channel model describing the doubly selective fading process with variable delay spread and variable Doppler spread (over time/distance) for two exemplary safety relevant scenarios. The developed channel model focuses on a low-complexity real-time implementation on a software-defined channel emulator. We analyze the clustering of multi-path components in the delay-Doppler domain using the local scattering function of channel measurement data from s afety relevant scenarios.
Based on the concept of cluster, we modify the traditional tapped delay line model, where a tap is related to a propagation path. In our case, we consider each cluster as one path in the modified delay line model with real valued and time-variant delay and Doppler shift. For the statistical analysis, we divide the cluster locations in the delay-Doppler plane into different characteristic regions. The time-variant cluster parameters, such as cluster birth rate, relationship between delay and Doppler shift, and the distribution of the lifetime and of the cluster gain in each region, are characterized firstly. For the real time channel emulation the cluster parameters are randomly drawn from this pre-analyzed distributions. Our model is validated with measurement data using the (time-variant) power delay profile, Doppler spectra density, as well as the cumulative distribution function (CDF) of the root mean square (RMS) delay spread and Doppler spread. A close match of our numeric real-time model with measurement results is shown.