Abstract

Satellite navigation (Sat-Nav) service is gaining popularity due to its use across numerous market segments in the public and private sectors. Several countries have their Sat-Nav system. Indian Regional Navigation Satellite System (IRNSS) is a newly developed regional navigation satellite system developed by the Indian Space Research Organization (ISRO), India. Like every other wireless system, characterization of the channel (or modelling of the propagation channel) is required for this IRNSS for further understanding of its performance and subsequent design improvement. The development of such a statistical channel model for IRNSS is the primary goal of this dissertation.

As the IRNSS is a newly developed Sat-Nav system, channel model characterisation is not available in the literature yet. The channel model captures the shadow fading with multipath which causes random fluctuations of the received signal at the receiver. The movement of the receiver makes the signal variation more dynamic. Capturing this dynamic range variation, a 2-state channel model is proposed in our work. The versatile Nakagami-Lognormal (NL) composite distribution function is used for both the channel states, and the $K-$means clustering algorithm has been used for the state separation. A measurement campaign has been carried out for the IRNSS system to record the fading data at the L5 band. Validation has been done after extracting the channel model parameters by nonlinear curve fitting method which constitutes the first ever study to extract statistical properties of IRNSS channel model. The fit of the proposed channel model is tested quantitatively by measuring metrics like Mean Square Error (MSE) and the Kullback-Leibler (KL) divergence. It has been shown that the proposed model is suitable for capturing the combined effect of random shadowing and multipath in the received IRNSS signal, as the model matches the measured data very closely.

We have proposed using an analytically simple mixture distribution to model a wireless channel in the next work. Several composite fading distributions are

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available in the literature to model the randomness due to the multipath fading and shadowing. Among them, Lognormal based models are unable to give a closed-form expression of the composite distribution, but the Gamma-based model overcomes the problem faced by the former one. However, the Gamma-based model comes with a complicated mathematical function. In order to overcome that, the mixture of Lognormal (MoLN) distribution is used in this work which is analytically more simple than the popular composite distributions. The maximum-likelihood approach is used for parameter estimation with the help of the expectation-maximization algorithm. Simulation results have been provided to show the accuracy of the proposed mixture model for various channel conditions. The approximation framework remains valid for a wide range of channel model parameters. The first-order statistics of both the envelope and signal-to-noise ratio of a wireless channel are represented by simple mathematical forms.

Continuing the effort, in the subsequent work, we have applied the proposed MoLN distribution to model the IRNSS channel. Similar to the first work, validation has been done using measurement data. Here also the quantitative metrics have been calculated to confirm the fit of the model.

Finally, we have analyzed the performance of a wireless system over this MoLN distributed wireless channel under the RF impairments, which gives us more practical insight. The requirement of low cost, highly integrated hardware paves the way for direct conversion architecture for modern wireless communication systems, more so in satellite communication system. Still, it comes with inescapable RF impairments, namely phase noise, amplifier non linearities, and in-phase quadrature-phase imbalances (IQI). Owing to such impairments, performance of the system degrades. In this work, an assessment has been done to quantify the adverse effects of RF IQI on wireless communication systems over the Mixture of Lognormal (MoLN) distributed fading channel. Performance of such wireless systems in terms of outage probability (OP) has been derived. A generic expression for the average symbol error rate (SER) has been obtained and inspected for the M-ary Phase Shift Keying (M-PSK) modulation scheme. The obtained analytical expressions have been validated through simulation.

Keywords: 2-state channel model, Average SER, EM algorithm, IQI, IRNSS, KL divergence, $K-$Means clustering, MoLN distribution, M-PSK, MSE, NL distribution, RF impairments, State Probability Matrix.

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