Simulating Correlated Shadowing in Mobile Multihop Relay/Ad-hoc Networks

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Zhenyu Wang, Eustace K. Tameh, Andrew Nix
University of Bristol
Merchant Venturers Building, Woodland Road
UK BS8 1UB
Voice: +44 (0) 117 954 5169
Fax: +44 (0) 117 954 5206
E-mail: Zhenyu.Wang@bristol.ac.uk, Tek.Tameh@bristol.ac.uk, Andy.Nix@bristol.ac.uk
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Introduction

• This document investigates the joint spatial/temporal correlation property of the shadowing process for peer-to-peer radio links in urban environments.

• A Sum-of-Sinusoids (SOS) based joint shadowing process simulation model is proposed to support the system level simulation of multi-hop and ad-hoc networks.

• The model is used to produce a correlated shadowing map and these could be used to harmonize the system level modelling of candidate 802.16j systems.
Background

• In multi-hop/ad-hoc networks, a large number of simultaneous communication links occur between mobile terminals.
• it is essential to use a radio propagation model with jointly correlated shadowing for the mesh peer-to-peer links.
Background (2)

- For the analysis of routing protocols and radio resource management (RRM) algorithms, a proper shadowing model must cope with dual mobility and interference in mesh peer-to-peer links.
- Previous work in the European Union IST Romantik project demonstrated that relay simulations produce false results if uncorrelated shadowing is used in the system level simulator.
Shadowing spatial correlation property

- The shadowing correlation is analyzed by using channel data generated from a fully 3D deterministic propagation model.
- The ray tracing simulations were conducted in central Bristol in the 2.1GHz and 5.2GHz bands.
Shadowing spatial correlation property (2)

• Findings from the analyses
  • The shadowing fluctuations are mainly caused by changes in the surrounding buildings near to the MS due to movement.
  • An exponential decay function accurately models the spatial auto-correlation function of the shadowing fluctuations.
  • The joint correlation property of the MS-MS channel shows an independent and equal effect on the correlation coefficient for MS movement at each end of the link.
  • The shadowing spatial joint-correlation function can be decomposed into the combination of two independent 1-D spatial auto-correlation functions.
Simulation Model

• A Sum-of-Sinusoids (SOS) based model is developed to generate the joint shadowing process for system level simulation.

• The underlining principles:
  • A Gaussian random process can be approximated as an finite sum of sinusoids;
  • The correlation property of a Gaussian process is determined by its power spectrum, i.e. its power spectral density (PSD) function can be derived from the Fourier transform of its correlation function.

• The Shadowing fluctuations are modelled as a 4D Gaussian process, with the \{x,y\} locations of the transceivers at each end of the radio link used as input variables.

• The Discrete Monte-Carlo Method (DMCM) is proposed to sample the PSD. This ensures a fast simulation time, even for large network sizes.

• Numeric results show that the proposed model accurately reproduces the required correlation property.
Simulation Model (2)

• The model generates a random shadowing map that is defined and efficiently stored in terms of a set of parameters.

• The exact shadowing value is determined by the Tx/Rx locations and calculated on demand during the system level simulation. All shadowing values are repeatable.

• The model can be easily implemented using a look-up table and hence offers fast simulation speeds.

• The model is periodic in the spatial domain: The radio nodes can be considered to lie on the surface of a toroid. This avoids interference edge effects, and is suitable for large network simulations.
Summary

• The spatial correlation of urban peer-to-peer channels in urban areas has been investigated based on channel data derived from a 3-D ray model.
• The shadowing auto-correlation function can be well represented using an exponential decay function.
• The spatial joint-correlation function can be decomposed as the combination of two independent 1-D spatial auto-correlation functions.
• A correlated shadowing model has been proposed for 802.16j to produce standard shadow maps for incorporation in system level simulations.
• The shadow maps can be easily incorporated into network level simulators (Opnet, ns2, Qualnet). Example ns2 code is available on request.