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

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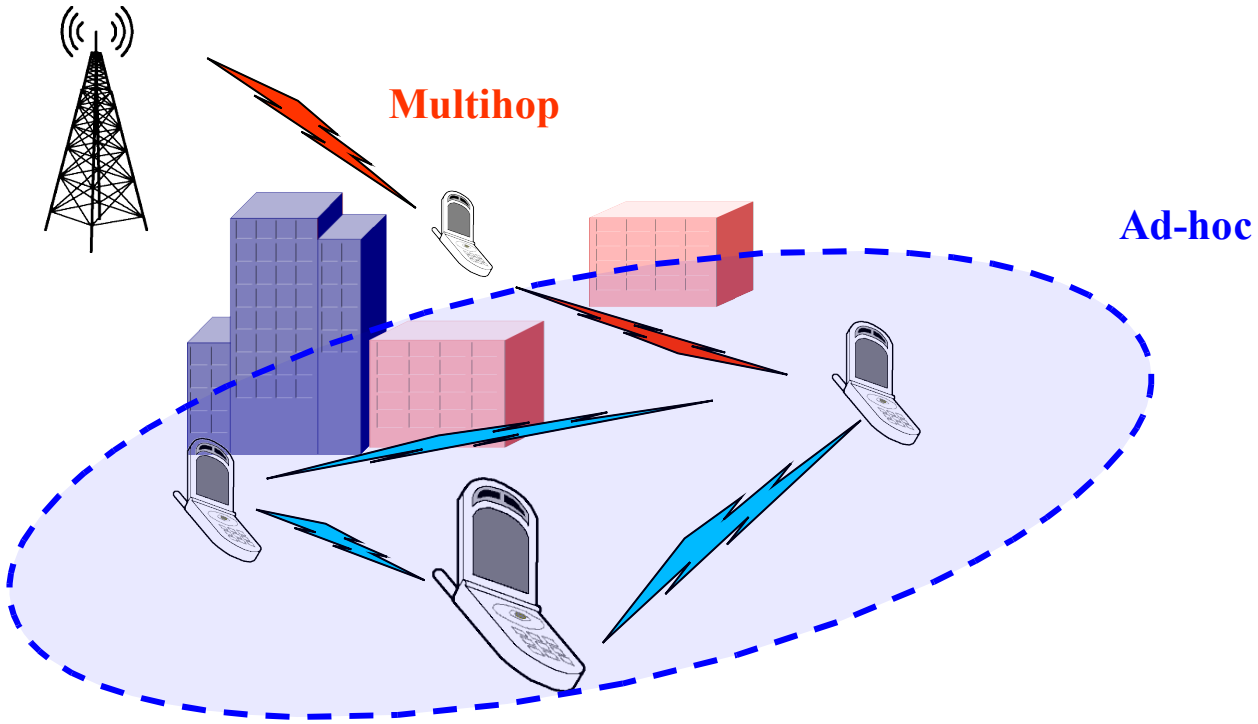
For approval and submission to IEEE 802.16j for system evaluation methodology

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.

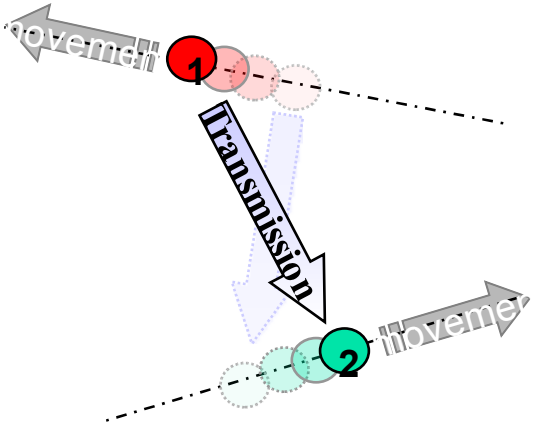
Background

- 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.

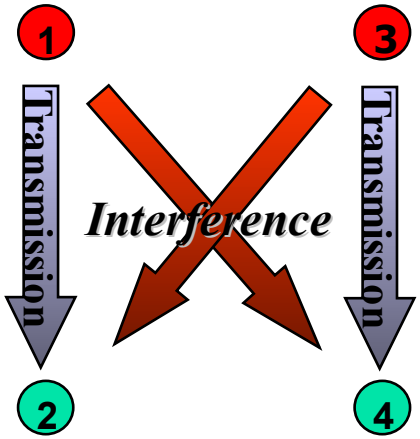


Background (2)

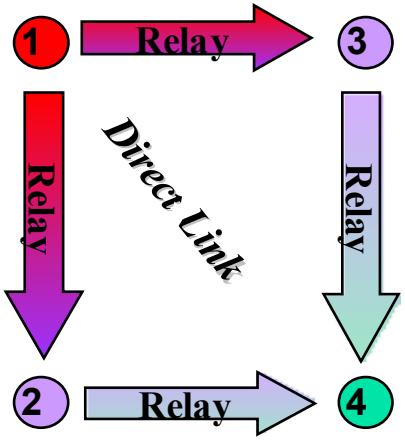
- For the analysis of routing protocols and radio resource management (RRM) algorithms, a proper shadowing model must cope with dual mobility and interference in mesh peer-to-peer links.
- Previous work in the European Union IST Romantik project demonstrated that relay simulations produce *false* results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



Dual mobility
in peer-to-peer link



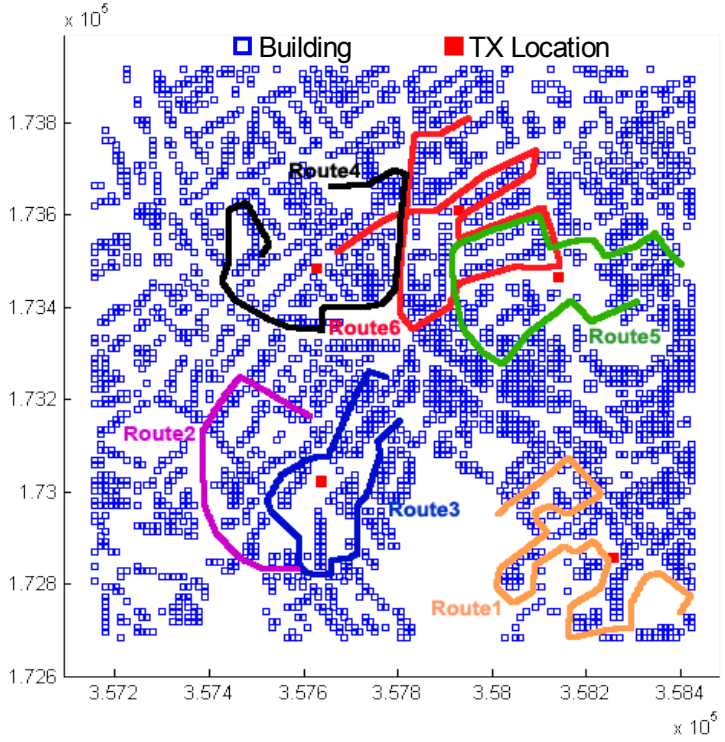
Interference in mesh
network



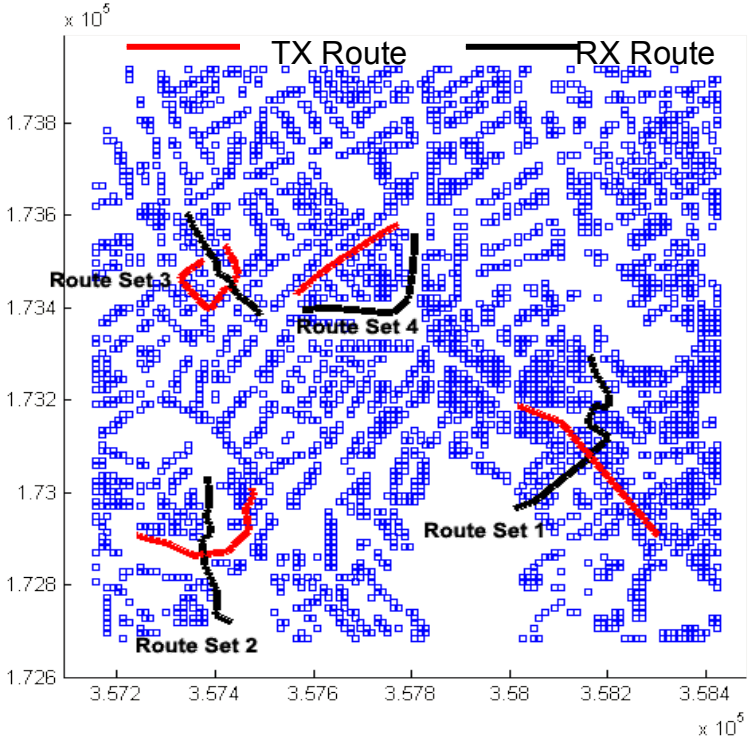
Relay in
multihop/Ad-hoc
network

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.



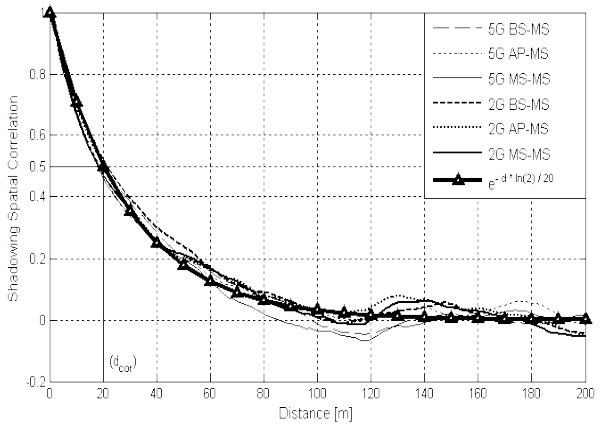
Single terminal mobility scenario

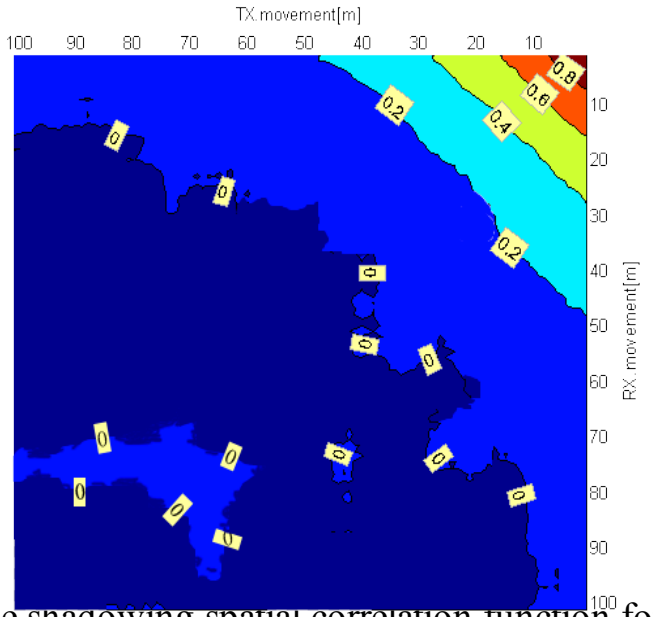


Dual terminal mobility scenario

Shadowing spatial correlation property (2)

- Findings from the analyses
  - The shadowing fluctuations are mainly caused by changes in the surround 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.





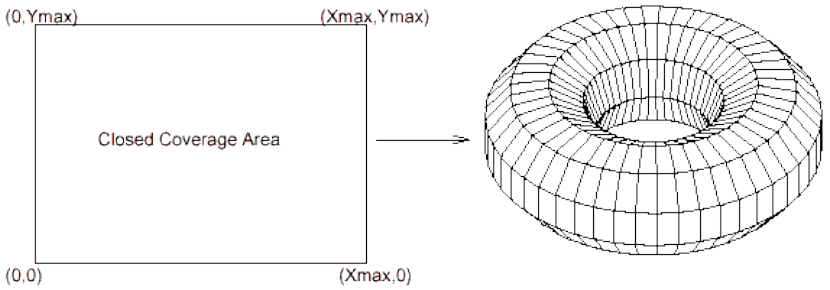
The shadowing spatial correlation function for Single (top) and dual (bottom) terminal mobility

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.