EXPERIMENTS, DATA ANALYSIS, AND MODELLING OF PROPAGATION LOSS WHEN LIMITED SPACE INHIBITS SPATIAL AVERAGING FOR MULTIPATH MITIGATION

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ABSTRACT

It is well known that, for the modelling of propagation loss, one must eliminate small scale fading resulting from the interference of multipath waves. Once this done, a best it linear model to the relationship between the log of propagation loss, (or received power) as a function of the log of the distance between the measurement system transmitter and associated receiver is estimated, usually using regression analysis, based on least mean squared errors. Finally, a distribution of the log of the power ratio between the best fit linear model and measured data is estimated, and reported as a model for larger scale, or so-called shadow fading.

In the past, the elimination of small scale fading has most often been done by spatial averaging around a circle of diameter approximately one wavelength centred on receive locations, over the trajectory of a moving transmit antenna, or along the trajectory of a moving receiver. However, when the environment of operation is confined, such as in many office and other indoor environments, and wavelengths are larger (as, for instance at low VHF, and even in the 700 MHz band of much current interest), such spatial averaging results in problems. First, there just may not be the required space. Secondly, usually used averaging diameters and linear distances can span locations among which obstruction loss changes. Thus, the spatial averaging for elimination of small scale fading distorts information concerning larger scale (shadow) fading, and the autocorrelation properties thereof. The latter are of interest in designing power control algorithms.

The mitigation or elimination of multipath-induced small scale fading by averaging over space simply is simply an estimation of running mean of powers resulting from the vector addition of multipath waves, the phases of which vary in space, (and in time, if there is motion). Similar results can be accomplished by summing the powers of impulse response estimate samples, which is equivalent to averaging over the bandwidth of a wideband signal, taking advantage of frequency diversity. However, in the latter case, to be effective, the averaging needs to be over a bandwidth greater than the coherence bandwidth of the measured channel. Often, in current times, this is impossible as a result on restrictions of bandwidths available for channel sounding by spectrum regulators.

Two alternatives to averaging over frequency or space are the super-resolution of multipath waves (to prevent vector addition) in accordance with either their relative delays, or their angles of incidence at the measurement system receiver, followed by the addition of the powers of the resolved multipath signals to arrive at a total received power.

This presentation to be given will report results from the MUSIC high resolution analysis of swept frequency channel soundings with 18 MHz bandwidth centred on 725 MHz, 2.4 GHz and 4.9 GHz to resolve multipath signals for the construction of a path loss model for line of sight conditions in the hallway of a building. Multipath arrivals are super-resolved in delay based on correlation matrices estimated from 10 measurement snapshots over a receive antenna travel distance of 25 cm to mitigate multipath-induced receive power variations and arrive at a path loss model as described in the opening paragraph. This modelling is also accomplished by super-resolution in accordance with angle of arrival at overlapping synthetic apertures, each synthesised using data at single frequencies in channel transfer function estimates, over 2 wavelengths of travel by the measurement system`s receiver along a linear trajectory. Results for the two cases are shown to be almost identical with each other and to a result from averaging over space and frequency, and to conform with crude ray tracing results (with all reflection coefficients fixed at unity) for seven rays in the hallway where the measurements were made. Results also show large scale fading as a result of multipath interference in the hallway, where there was no shadowing by obstructions. Finally, comparisons will be made among results for the three frequency bands.

Conclusions are: (1) that spatial averaging can obviated using super-resolution analysis to resolve multipath signals in accordance with either propagation delay or angle of arrival, and (2) that so-called shadow fading can result from blockage of signal paths by obstructions (as usually assumed), multipath interference, changes in multipath interference (as reported previously by the principal author), or a combination of all three.

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