ANTENNA DIVERSITY ARRAY DESIGN FOR MOBILE COMMUNICATION SYSTEMS

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Diversity reception is a technique in radio communications to provide better spectrum efficiency with a cost of an extra set of antennas. The basic requirement of antenna diversity is to have more than one way to receive incoming electromagnetic waves provided usually by a multi-element antenna configuration. The reception modes should be as uncorrelated as possible since the received signal to interference ratio can be optimized in basis of the correlation properties of the signals. A well known example of the antenna diversity usage is the reduction of signal fading in multi-path environments such as downtown areas in large cities or indoor environments. Antenna diversity in its various forms and implementation techniques is found to be a very useful and cost-effective addition to many narrow bandwidth TDMA/FDMA-systems, as well as low-chiprate CDMA-systems. Applications of diversity reception include for instance cellular phone networks and wireless local area networks (WLAN).

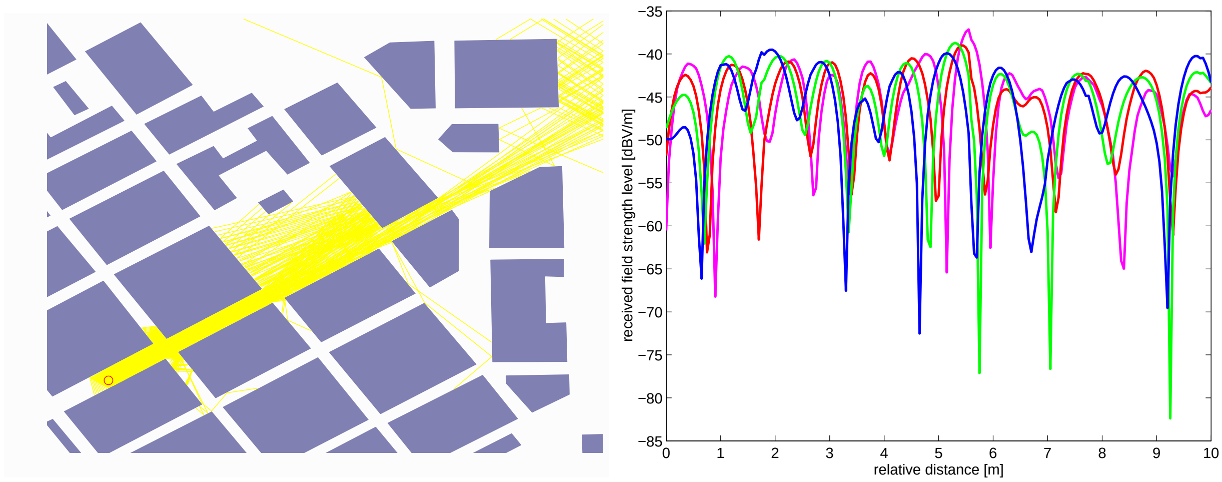


Figure 1: The simulated microcellular environment and an example of the received signals as a function of distance.

The operation of antenna arrays and its radiation properties are generally understood in the form of power patterns. Likewise, one approach to produce uncorrelated reception modes with antenna arrays is to create uncorrelated power patterns. However, array antennas inherently also have the possibility to vary their phase characteristics ie. the phase pattern [1]-[3]. This is another and quite opposite approach in utilizing array antennas and the antenna diversity concept.

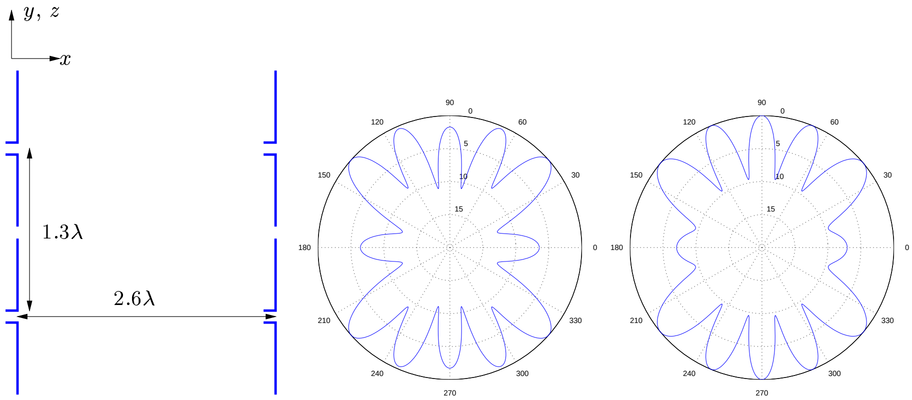
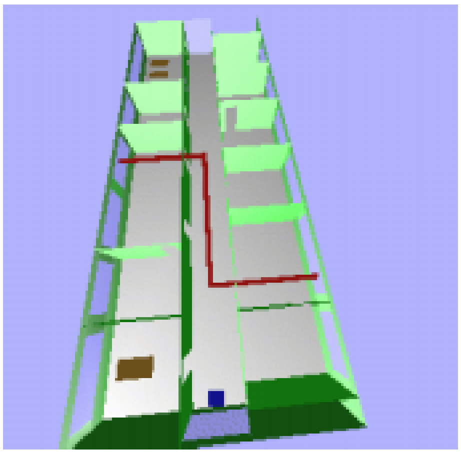


Figure 2: 2-dimensional diversity array and horizontal plane antenna patterns for both horizontal and vertical alignments of the array.

An antenna pattern synthesis method is introduced, which results in exactly the same power pattern but disssimilar phase patterns for the array. The theory of the pattern synthesis is rather general and can be applied for linear, planar or 3-dimensional array pattern design. The antenna patterns provided by the synthesis method can be applied in diversity reception while the dissimilar phase patterns offer uncorrelated signals to be utilized in reducing destructive interference. The antenna diversity would therefore be implemented in selection combining between the different antenna pattern excitation and thus fulfilling the desired coverage planning requirements.

This theoretical study of antenna array diversity is followed by assessments of the technique in various simulated surroundings. In a microcellular urban environment, where antenna heights are clearly below rooftops, a 2-dimensional radio channel simulation model is used. Wall reflections, corner diffractions and the ground reflection are taken into account in a city perspective as linear polarization is being used.

In an indoor radio propagation channel, reflections from the floor and the ceiling are important sources of signal interference, thus making the propagation environment more complex and prone to severe signal fading. A small 2-dimensional array (Figure 2) in a base station could be a simple but effective method to neutralize the effects of fading. The fading reduction performance is assessed from a signal response of a 3-dimensional ray-tracing radio channel program. The simulator program takes into account the polarization effects of the propagating signal, which leads to a good estimate of the signal correlation between different array responses and antenna diversity methods. The use of an antenna array in a base station provides means to design the radiation pattern according to coverage needs and, on the other hand, to utilize the signals in all array elements in diversity reception.



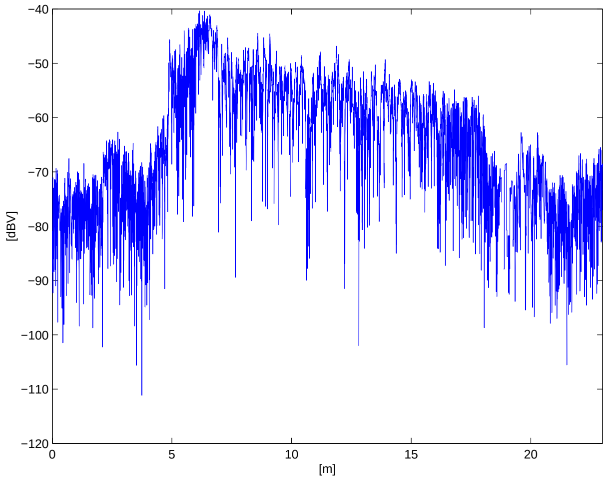


Figure 3: The simulated office environment and the corresponding receiver signal response

References

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[2] J. Juntunen, K. Nikoskinen, K. Heiska, *"Binomial array as a multistate phase diversity antenna."* to appear in IEEE Transactions in Vehicular Technology.

[3] J. Juntunen, K. Nikoskinen, K. Heiska, *"Phase diversity arrays for mobile communication networks."* 10e Journèes Internationales de Nice Sur les Antennes (JINA'98), Nice, France, pp. 734-737, 17-19 November 1998.