AN EFFICIENT TECHNIQUE FOR MODELING WIDEBAND PROPAGATION IN AN URBAN PARALLEL STREET MICROCELLULAR ENVIRONMENT

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Abstract

This paper suggests an extended technique for modeling of wideband propagation in an urban parallel street microcellular environment. This technique is based on multiple equivalent sources. It makes parallel street propagation predictable by using a simple yet accurate method which has been successful for a side-street environment.

1. Introduction

It is important to develop reliable planning tools for future broadband communication systems in urban microcells. The lengthy time spent in ray tracing computation is a major problem with mobile radio propagation prediction for urban microcellular environments. The use of different values of permittivity and conductivity in the calculation of Fresnel reflection coefficients makes large difference in the prediction of multiple reflections [1],[2]. For the configurations where the transmitter is located in parallel streets referring to the receiver location, the ray tracing techniques appear unable to reduce up to 20-dB difference between measurements and predictions as seen in Fig. 8 of [1] and Fig. 16 of [2]. The ray techniques of single and double diffractions with multiple reflections remain also to be unsuccessful for parallel street problem. These may expose the limitation of existing ray tracing techniques.

The purpose of this work is to present a multiple equivalent source technique which is found to be a solution to parallel street problem. This technique makes the parallel street propagation predictable using a simple yet accurate method which has been successful for a side street environment. This technique is fast in computation and more accurate than the existing ray techniques. The technique avoids the difficulty of choosing the values of permittivity and conductivity, since only a few reflections in the main street referring to the receiver location, are considered.

0-7803-5639-X/99/$10.00

2. The Modelling Method for Channel Transfer Function

In the propagation problem studied in this paper the transmitter (Tx) is at a parallel street location for receiver (Rx) location in the main street (see Fig. 1). For this problem the single equivalent source technique was introduced and explained for narrowband path loss prediction in [3]. The technique is presented in this paper utilises several of equivalent sources. They are used to derive the channel transfer function. The main condition of the this technique is that the receiver must be kept in shadow zone of the multiple equivalent sources. In the case of Fig. 1 the multiple equivalent sources are placed on the side streets A, B, and C at different distances from the out-of-sight southern margin of the main street where the transmitter and its images are located. Examples of the possible approximate locations of the equivalent sources for side street B are shown in Fig. 1. The distances are found from the direct spherical wave incident on the west wall of side-streets A, B, and on the east wall of side-street C from the transmitter and its images. These incident points are at the out-of-sight margin of the main street where the transmitter and its images are located. In summary, the multiple equivalent source technique transforms the parallel street problem to the calculation of transfer function for the side street environment. Two-dimensional (2-D) ray methods are used in the derivation of channel transfer function, neglecting over-rooftop diffraction and ground reflections. If required, the directional wideband channel transfer function for antenna array can be found in the same way as in [4].

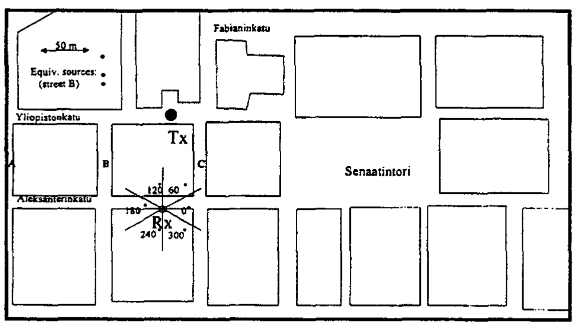


Fig. 1. Microcellular propagation environment.

3. Measurement Setup

The measurements were carried out in the city center of Helsinki, Finland [5]. The measurement system (Fig. 2) consists of a wideband channel sounder with single receiver and a radio frequency (RF) switch that separates received signals from 8 receiving antennas. To obtain full 360° azimuth coverage, the measurement was performed in six 60° sectors. The transmitter and receiver antennas were nearly at the same height. The carrier frequency of the sounder is f_0 = 2.154 GHz. The chip frequency is f_c=53.85 MHz giving delay resolution of about 20 ns [5]. The measured impulse responses from the 8 receiver antennas are used to estimate parameters of wideband propagation.

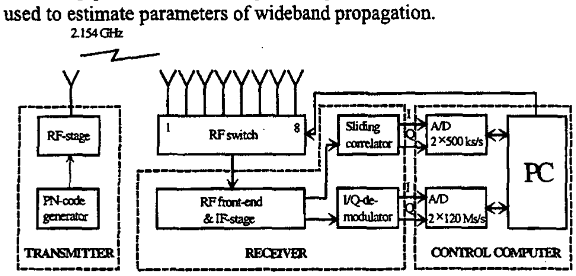
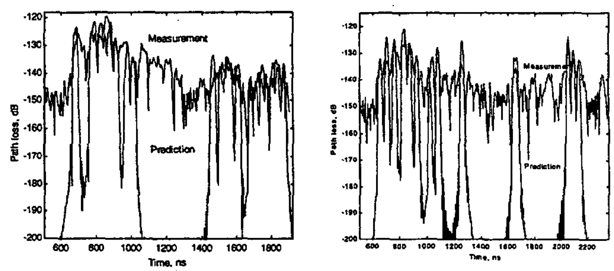


Fig. 2. Measurement system.

4. Wideband Characteristics

a) Time Domain Characteristics

Fig. 3 presents the results of the measured and predicted time domain characteristics of the multipath channel for the first element of the receiving antenna. Agreement between predictions and measurements is evidenced. In Fig. 3a, the sector centered at 180° represents propagation paths via side streets A and B respectively and in Fig. 3b, the sector centered at 0° represents propagation paths from side street C and the square area as shown in Fig. 1.

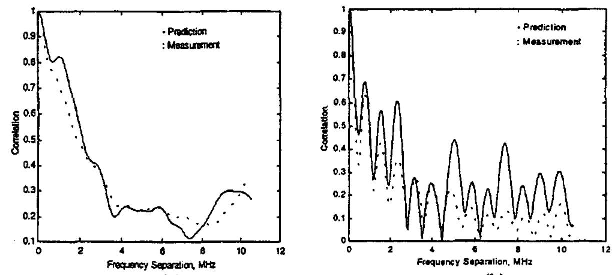


(a) (b)

Fig. 3. Time domain propagation for sectors centered at 180° (a) and 0° (b).

b) Frequency Correlation

Fig. 4 presents magnitude of channel frequency correlation function of predictions and measurements. Low correlation is evidenced as the frequency separation increases. The limited coherence bandwidth is a serious problem for adaptive antenna down link beam forming in frequency division duplex (FDD) systems. The knowledge of frequency correlation is necessary for choosing subcarriers of communication systems employing frequency diversity.



(a) (b)

Fig. 4. Magnitude of channel frequency correlation function for sectors centered at 180° (a) and 0° (b) directions.

5. Conclusion

A new multiple equivalent-source technique, which is an extension of existing work [3] that used a single equivalent source, is presented. The original work is used for narrowband path loss prediction, the extension is used here for modeling wideband propagation prediction in an urban parallel-street microcellular environment. This technique is fast in computation and can avoid the difficulty of determining the values of permittivity and conductivity for multiple reflection.

References

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