UHF WIDEBAND MOBILE RADIO TIME DOMAIN CHANNEL PARAMETERS ESTIMATION BASED ON ENVIRONMENT RELATED STATISTICAL DATA

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ABSTRACT

This paper presents an estimation method of the time domain parameters of a UHF Wideband Mobile Radio Channel based on environment related statistical data.These mainly involve the scatterers location relative to the mobile position in three dimensional geometry. The scatterers are randomly distributed in a homogenous environment and act as second waves sources transmitting a single ray in the receiver direction. One of map-derived statistical parameters determines the reflection coefficient of scatterers by calculating their approximated bistatic radar cross-sections. The model has been tested against measured channel statistics obtained from a field trial made at Rennes, France, in the form of the probability density of occupancy as function of excess delay time. Some promising results are obtained, especially in suburban sites.

1. INTRODUCTION

The mobile radio propagation in an urban environment is generally characterized by strong multipath effects. The components of the signals reaching the receiver would usually have undergone attenuation, reflection, and diffraction caused by buildings and other geographical features. As the location of the mobile varies, this phenomenon appear as time and space selective fadings on the received signal. Hence the knowledge of channnel characteristics, in particular, its time domain parameters, i.e., the impulse response, seem to be useful for improving the communication system performances by using, for example, several diversity techniques [1].

There have been few published papers on UHF wideband mobile radio channel models which take into account environment related statistical parameters. Zander [2] proposed a stochastical model based on an optical analogy which can be well justified at this band. The model assume randomly scintillating and randomly distributed scatterers and it allows for the path-length estimation but without the wave intensity variation. Recently, Bajwa [3] has refined the Zander's model by introducing the Huygen's reradiation principle to discrete randomly distributed and randomly scintillating scatterers allowing for the wave intensity variation estimation due to wave divergence. Inspite of their interesting results, these models exclude the scatterer heights, i.e., they are two dimensional models.

The model presented in this paper concerns a three dimensional model. The scatterer heights are implicitly introduced in the calculation of their approximated bistatic radar cross-sections. They determine the reflection coefficients of scatterers. The environment related statistical data are automatically extracted from existing ordnance survey maps. They mainly include the distances between the scatterers and the mobile, the angular location of scatterers in respect to the mobile position and the scatterer reflecting surfaces leading to the approximated bistatic radar cross-section calculation.The model has been tested against measured channel statistics obtained from a field trial made at Rennes, France, in the form of the probability density of occupancy as function of excess delay time.

2. MULTIPATH CHANNEL MODEL

The model suppose that a single reflection is the principal mode of scattering. Each scatterer is randomly distributed but equally alligned to the same direction in a homogenous environment and acts as a secondary source of radiowaves. The scatterers are geometrically modelized as boxes having vertical, plane and relatively smooth surfaces. The waves reaching at the proximity of the mobile are assumed to be plane and to be vertically polarized.

2.1. Scatterer geometry.

A general view of a scatterer hypothetical situation is shown by Figure 1. The vectors $r_k = 1, 2, 3, \ldots N$ represent the distances between the mobile and the N scatterers. Each of them has one or several reflection coefficients determined by the corresponding approximated bistatic radar cross-section.

This can be calculated by using a very simple relationship between the monostatic and bistatic cross-sections as long as the reflecting surfaces have a simple shape(flat plates), sufficiently large compared to the operating wavelength and sufficiently smooth [4]. The corresponding expression of the bistatic radar cross-section is given after [4] by :

$$\rho = \frac{h^2}{\pi}\left[n\ l\ \cos\theta \, \frac{\sin(n\, l\, \sin\theta)}{n\, l\, \sin\theta} \right]^2 \tag{1}$$

This is the equivalent monostatic radar cross-section of a flat plate with an aspect angle of θ, where 2θ is the bistatic angle for the transmitter-receiver direction, h is the height of the scatterer's illuminated surface, l is its width and $n = 0, 1, 2, \ldots$

The relative time delay τ_k due to the wave originating from the k^{-th} scatterer can be calculated by the following relation, (refer to Fig.2):

$$\tau_k = \frac{d_k \cos(\phi_k) + \sqrt{\left(\frac{h_k}{2}\right)^2 + d_k^{\,2}}}{c} \tag{2}$$

where d_k is the projection of r_k on the floor with r_k is the distance between the k^{-th} scatterer and the receiver, f_k determine the relative angular position of the k^{-th} scatterer, h_k is its height and c is the light velocity.

The reflection coefficient of the k^{-th} scatterer in the receiver direction is given by :

$$\rho_K = \rho \, \frac{\cos\left(\frac{\theta_K}{2}\right)}{\cos\left(\phi_K\right) . \cos\left(\beta_K\right)} \tag{3}$$

θ_k is the aspect angle on the surface , f_k et b_k determine the relative angular position of the k^{-th}

scatterer.

It is then possible that the time domain parameters of the channel can be estimated directly from the experimental distributions of r_k, ϕ_k and ρ_k in the form of the probability density of occupancy as function of excess delay time $p(\tau)$, which is expressed as :

$$p(\tau) = p(r_k)\, p(\phi_k)\, p(\rho_k) \qquad (4)$$

by supposing that $p(r_k)$, $p(\phi_k)$ and $p(\rho_k)$ are independent to each other.

2.2. The environment related statistical parameters

The environment related statistical data are automatically extracted from existing ordnance survey maps on a 1:2000 scale. We can extract :

a) the distance **r** connecting the scatterer and the mobile, leading to the estimation of the probability density p(r).
b) the angular position ϕ of the scatterer in respect to the mobile, leading to the distribution $p(\phi)$.

However the building heights are not always mentioned on the maps. Hence, the distributions of reflection coefficients $p(\rho)$ and that of the scatterer elevation $p(\beta)$, could be determined by doing an inspection in the site. In other words, h_k is estimated in the site, whilst d_k et f_k are directly extracted from the maps.

3. RESULTS

The model has been tested against measured channel statistics obtained from a field trial made at Rennes, France [5] in the form of the probability density of occupancy as function of excess delay time. The experimental probability is obtained by counting the number of echo profiles in which the echo amplitude in the chosen delay interval exceeds a preset threshold, whilst the experimental probability based on map-derived statistics is calculated by using the equation 4. Figure 3a. represents the experimental probability density of occupancy corresponding to suburban data. On the other hand, the probability density estimated by the environment related statistics of the same site is shown in Figure 3b. An inspection on this two distributions shows a good agreement. However, the map-derived distribution seems to be suitable for a small scale estimation and identifiable environment features.

4. CONCLUSION

An estimation method of the UHF wideband mobile radio channel time domain parameters has been presented. The comparison between experiment and map-derived results is obtained in the form of the probability density of occupancy as function of excess delay time. The results seem to be promising. However, more tedious map works would be necessary for testing the model in other different type of sites.

5. REFERENCES:

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6. ACKNOWLEDGEMENTS:

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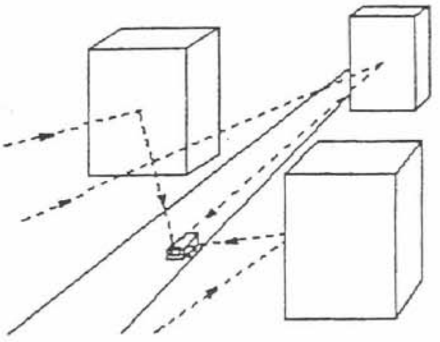


Figure 1: General view of scatterers

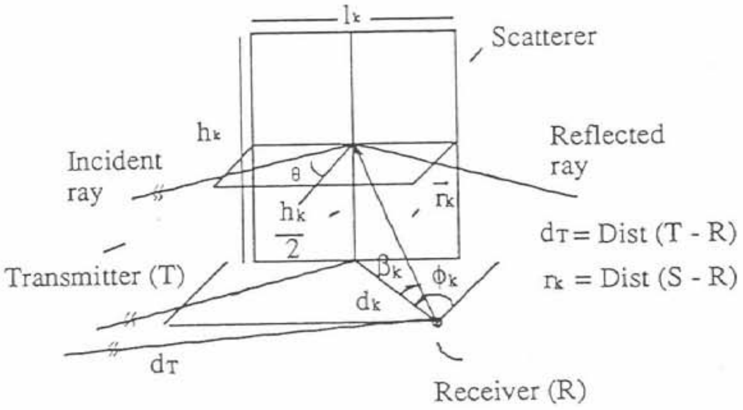
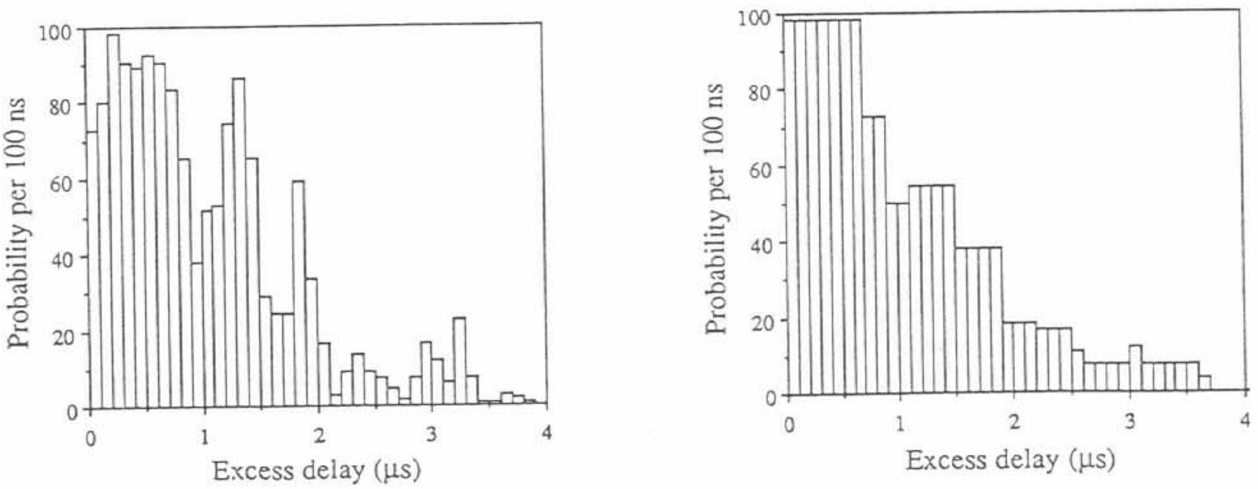


Figure 2: Scatterer geometry



a) Experimental

b) Map derived

Figure 3 : Probability density of occupancy