Mobility Effects on WCDMA Receivers in Indoor Areas

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ABSTRACT

This Paper presents important results in analyzing the effects of mobility on WCDMA receivers. It takes a completely different approach in translating the effects of mobility on WCDMA receivers. The mobility here is translated to a variable time delay assigned for each received multipath components. Indoor areas are considered in this paper.

Keywords: Birth-Death, Synchronization, Delay Spread, Timing error, Fading.

INTRODUCTION

The wireless communication channel affects the transmitted signals by two kinds of fading, small scale and large scale [1]. Small scale fading is referred to multipath fading which destroy the signal due to constructive or destructive addition of multiple received copies of the original transmitted signal [2]. Research shows that the number of the received multipath components can vary depending on the surrounding environment, the mobility of wireless receivers or mobility of objects surrounding it [3].

The effects of mobility appears to be included in channel dynamics, or by other meanings the variation rate of the received signal amplitude and phase [4]. This assumption is valid, however a very important factor seems to be ignored and not considered when studying the effects of end users mobility, which is the time delay of each received multipath component.

Few authors paid attention for this factor [5,6,7] however there studies are not based on a thorough investigation of the effects of time delay when end users are in a mobile state. Therefore this lead to suggesting techniques in the received side to tackle the generated problems due to mobility which does not treat the core problem mobility causes as this paper showing.

Authors in [7] shows that the end user mobility as well as the environment can cause the time delay for each multipath component to vary with time. It also shows that mobility in indoor areas will cause the multipath components to arrive in a birth-death fashion. Subjecting a wireless system to such an environment is shown in [8]. The authors suggested a multipath searcher technique which seeks for the strongest path through time, an improvement in the BER is noticed when the technique is applied.

In [8] the Birth-death multipath fading time delay variation is presented and the paper shows how to generate this behavior in a laboratory. Different parameters which controls this variation are explained and different scenarios are applied in testing a WCDMA receiver over such conditions. The testing results are presented in BER form.

This paper shows how to analyze the mobility effects in a completely different approach than the classical method which relates the mobility issue to how fast the envelope varies with time as mentioned earlier. The results presented in [8] are considered for the purposes of this paper. These results are analyzed statistically, then it shows which part in the receiver is the defected part. The analysis is based on [9] approach, which is based on statistically modeling the effects of multipath fading on synchronization circuits in WCDMA receivers. The analyses shows a match with the test results in [8]. The conclusions derived from this paper allows a precise development for techniques which will tackle the effects of mobility in indoor areas on WCDMA receivers.

The paper is organized as follows: section (1) explain the scenario used for testing. Section (2) analyses the results of simulating scenario described in section (1). and finally section (3) concludes the results of this paper.

1 SCENARIO DESCRIPTION

The birth-death behavior of MPC's is known to appear at indoor areas due to the movement of users between rooms or floors or the mobility of objects surrounding the users, this is illustrated in figure (1).

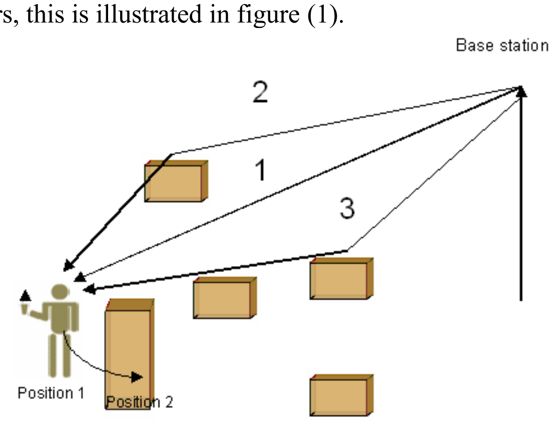

Figure (1): Scenario Describing the Movement in Indoor Buildings

When testing this scenario using the approach described in [8], the test results shows that the BER in a birth-death scenario increases compared to a static scenario. This increase is referred to power losses due to misalignments between the incoming signal and the locally generated code at the receiver side. To prove this, the Fokker Planck equation developed by [9] is used and the time delay factor in it is varied to follow an exponential distribution values.

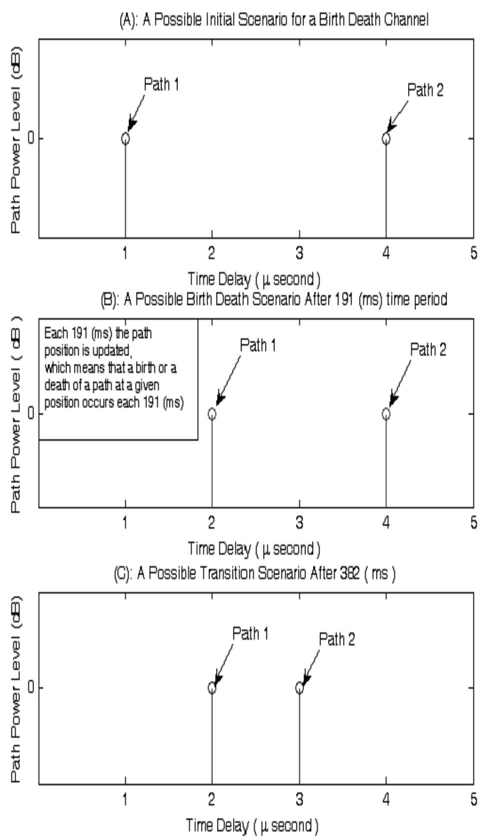

Figure (2): The path movement through time according to a Birth-Death Scenario.

The paths take place in one of the following values through time as shown in figure (2), 0 ns, 1000 ns, 2000 ns, 3000 ns, and 4000 ns. If these values are described in terms of Tc then it will equal 0, 3.81 Tc, 7.63 Tc, 11.45 Tc, 15.26 Tc. The figures on the left of the decimal point will be ignored as it is integer multiple of Tc, only figures on the right decimal point are in our interest, where it represents shifts in the received signal phase related to the ideal phase position which is 0. For the sake of analysis and to be compatible with birth-death time arrival rate which is exponentially distributed, the average mean of the delay positions is to be taken into account; Where if the actual points are only taken into account a linearly decreasing value will be generated and this will not satisfy the exponentially decreasing condition, in this case the average mean is 0.5375.

2 BIRTH-DEATH SCENARIO ANALYSIS

Figure (3) shows that the error generated due to variation in time delay values due to user movements in indoor areas varies with time as well. The error values are shifted according to the time delay value.

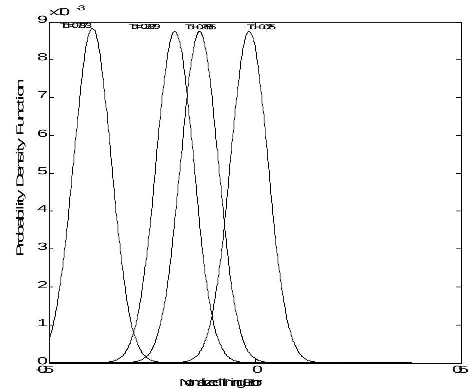

Figure (3): The PDF of normalized timing error for the scenario described in figure (2).

The delay values in Fokker-Planck equation are generated using a MatLab function that generates exponential distributed values. This means that the mean value of the data and the number of points the function needs to generate around that mean. When the programme is executed Td took the following values, 0.0275Tc, 0.7873Tc, 0.2685Tc and 0.3879Tc. These values are used as inputs for the Fokker-Planck equation which caused the normalized timing error PDF to shift to different potions according to the delay value, which in turns generated different power losses with each delay.

Referring back to figure (3),it shows that the initial position of the timing error $\varepsilon = 0.022$ with a probability approximately equals 1.8×10^{-5} which corresponds to Td = 0.0275Tc. The generated timing error shifts the locally generated code and aligns it with the received code at $\pm 0.022Tc$, this will introduce misalignment between the local code and received code which will be translated to a -0.008 dB losses. Figure (4) explains how those losses are generated.

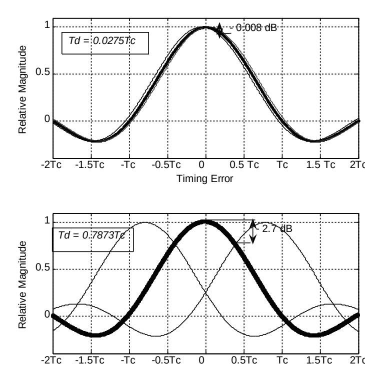

Figure (4): Power Losses Due to Misalignments

When the received signal arrives with a certain delay it will generate an error value which is obtained using the normalized timing error PDF $p(\varepsilon)$, then the error value with maximum probability is chosen as the most likely to happen, then the amount of loss caused by this error value is found by the crossing point value between the zero error timing signal and the shifted signal, thus the crossing point which is represented in relative magnitude units is to be converted to decibels.

The same analysis is to be applied for the other time delay points, where the second time delay position due to the birth-death behavior is at 0.7873Tc, the error value with highest probability value which is 1.8×10^{-5} that corresponds to this amount of delay is 0.3935Tc, this error will introduce a – 2.7 dB losses, then the time delay value jumps to take another value which is 0.2685Tc, which translates to a 0.134Tc timing error, and this will introduce a -0.3 dB losses. The last value the time delay will have during a simulation cycle for the generated scenario to test the birth-death effect is 0.3879Tc, which will generate a 0.194Tc timing error which is translated to a – 0.63 dB loss.

3 CONCLUSION

The effects of mobility in indoor area do not only affect the power level of the transmitted signal through the destructive and constructive addition but also the power level of the transmitted signal can be affected by the synchronization errors which is caused by mobility of end users or objects around them. The severity of power fade in this case depends on the delay spread values and how it controls the resulting normalized timing error probability. Solution based on RAKE receiver combining will not combat losses generated by misalignments between the local and received code. Any receiver development should take into account the losses generated due to synchronization errors otherwise the design will not be optimum.

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