An Interference Mitigation Technique by Exploiting Orthogonal Pilot Classes

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Abstract: In this paper, a pilot design method for wireless mobile communication system is proposed. All pilots available for assignment are classified into orthogonal classes that every pilot in each class is orthogonal to the pilots located in other classes. When a mobile moves in its pilot signal transmission, it's suffered various interference levels ensuing from different RF environments of the status changes of its neighboring base stations and mobiles, and consequently resulting in time varying system performance. With the assignment of the orthogonal pilot classes the system performance can be maintained at relatively constant level by adaptively assigning pilots to mobiles to have these pilots orthogonal to each other.

1 INTRODUCTION

In wireless mobile transmission, when a mobile user is transmitting data it will be affected by various interferences ensuing from other mobiles or its neighboring base stations, furthermore it will be a time varying interference when the mobile is moving since its RF interfering environment with other entities are changing. With this time varying interference level it will result in time varying system performance and consequently many interference mitigation methods have been proposed in order to assure constant system performance [1-5].

As shown in Fig. 1 it exhibits a normal cell arrangement of a base station with three sectors and its three neighboring base stations. With a mobile station (MS) locating in the sector closing to the cell center, as shown in Fig. 2, we will find, by simulation, its affected interference level from other two sectors that are belonging to other two BSs. From studying these simulation results we will try to develop a pilot's design algorithm to find proper pilots so that they will result in a minimum interference level for the situation as discussed in Fig. 2.

This paper is organized in the following. In Section II various interference environments or classes will be introduced. The interference mitigation methods for the interference classes as discussed in Section II will be exploited and proposed in Section III. Finally it draws a conclusion in Section IV.

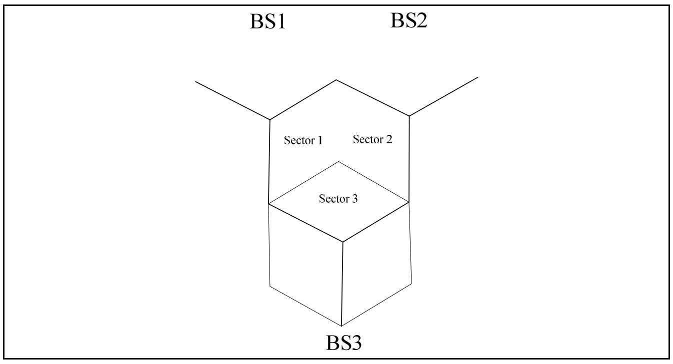

Figure 1 Three Neighboring BSs comprise Three Neighboring Sectors

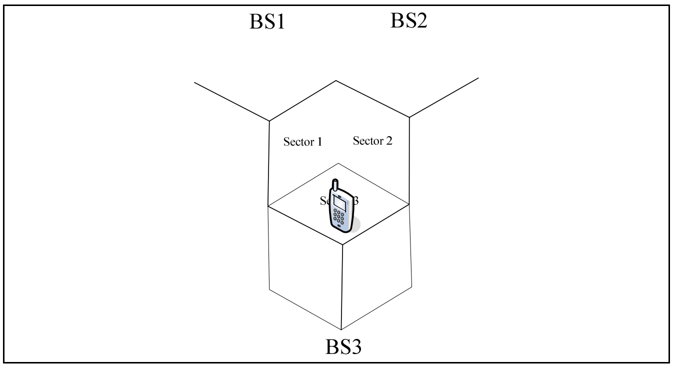

Figure 2 When an MS in a Sector Central Area its Interference Sources Coming from Two Sectors of other Two Neighboring BSs

2 INTERFERENCE CASES

Several interference environments are considered in the following:

Case 1: MS is stationary

As shown in Fig. 3 is a stationary MS, it stays in a fixed location of a BS, its neighboring two sectors are the interfering sources.

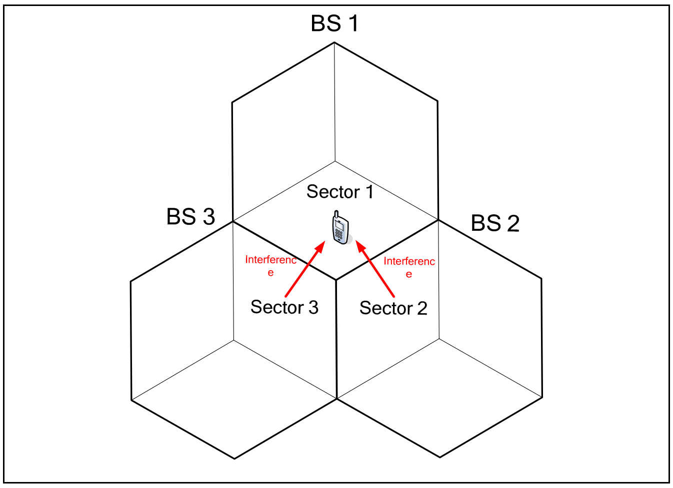

Figure 3 Neighboring BSs' Sectors are the Interfering Sources

Case 2: Mobility Scenario 1

When an MS moves away from its BS sector and enters into another BS sector the distances between the MS and these two BS sectors vary and consequently its RF interference level changes when the MS moves. An example as shown in Fig. 4 is an MS moving from sector 1 of BS1 (BS1-1) into sector 3 of BS3 (BS3-3), the interference level generating from BS3-3 increases due to its decreasing distance with the MS. By proper choice of pilot we can reduce the interference level generating from BS3-3 due to the mobile movement.

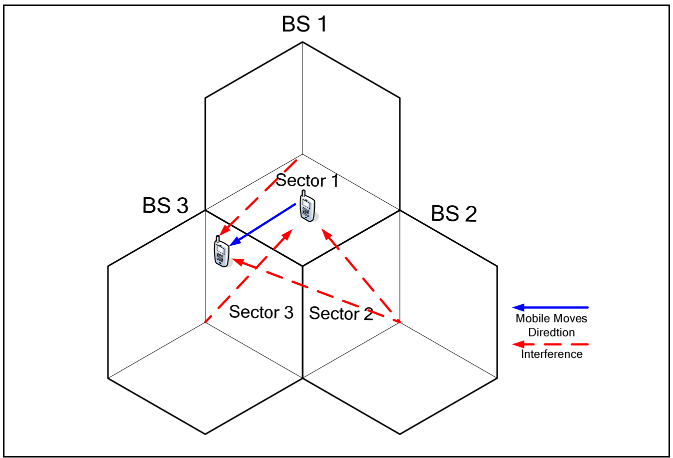

Figure 4 The MS moves from Sector 1 of BS1 (BS1-1) into Sector 3 of BS3 (BS3-3)

Case 3: Mobility Scenario 2

It is in the same interference environment as in Case 2 but now the MS is now moving along the cell edge as shown in Fig. 5. When the MS in BS1-1 moves along the cell edges of BS2 and BS3; its effected interference levels generating from BS2 and BS3 are increasing correspondingly since the distances between the MS and BS2 and BS3 are decreasing. From considering of a specific channel model [6-13] and if the same pilot, as shown in Table I, is allocated for all BSs, the MS will suffer the same interference levels from its neighboring BSs, its resulting interference level is shown in Table II. In Table I we introduce the 'interference weight' between two pilots from the consideration of their correlating relation; interference weight will be 1 if two pilots have the same pilot patterns.

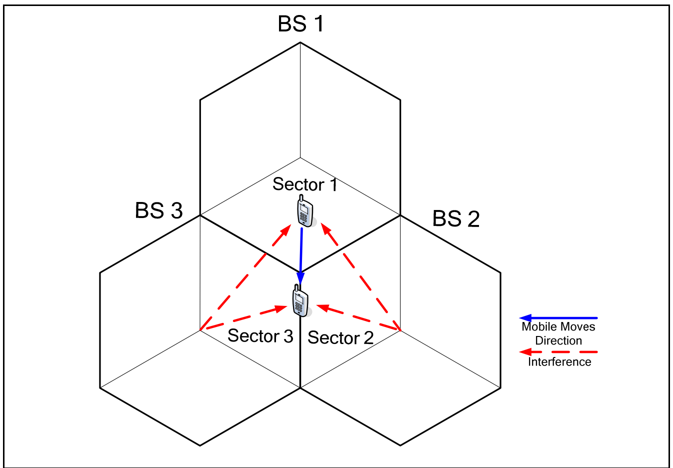

Figure 5 The MS moves from BS1-1 along the Cell Edges of BS2 and BS3

TABLE I ORIGINAL (CONVENTIONAL) PILOT ASSIGNMENT FOR EVERY BS SECTOR

BS1-1	BS2-2	BS3-3	Interference Weihgt BS1-1 & BS2-2	Interference Weihgt BS1-1 & BS3-3	Interference Weihgt BS2-2 & BS3-3
			1	1	1
			1	1	1
			1	1	1
			1	1	1

TABLE II PILOTS ASSIGNED FOR BSS SECTORS IN CONVENTIONAL PILOT ASSIGNMENT AND THEIR RESULTING SIGNAL STRENGTHS BETWEEN THE MS AND BSS SECTORS

BS1-1	BS2-2	BS3-3	Sensitivity (dBm) MS: BS1-1 Interference: BS2-2 & BS3-3	Sensitivity (dBm) MS: BS2-2 Interference: BS1-1 & BS3-3	Sensitivity (dBm) MS: BS3-3 Interference: BS1-1 & BS2-2
			-128.2400	-128.2400	-128.2400
			-128.2400	-128.2400	-128.2400
			-128.2400	-128.2400	-128.2400
			-128.2400	-128.2400	-128.2400

3 INTERFERENCE MITIGATION

From the simulation results as discussed in the above section, it is imperative to develop pilots' assignment algorithm to ensure constant interference level and consequently constant system performance when different interference environments are encountered.

With a BS consisting of three sectors as considered in IEEE 802.16m, it can classify the available pilots into three classes that the pilots in one class are orthogonal to the pilots allocated in the other classes [1-5]. In the assignment of a pilot for a BS, the BS has its choice by selecting the pilot from the class that is orthogonal to other pilot classes that are currently used by its neighboring BSs; therefore when an MS moves and it realizes that its interference level becomes higher as it closes to a BS it can select a pilot from the class that is orthogonal to the pilot class that is allocated to the coming BS so that to reduce its coming interference level. The design principle of pilot selection can be summarized in the following:

1. When the MS is located in the central area of the cell, i.e. when it is far away from other BSs, as shown in Fig. 6, it has less interfering levels and the pilot patterns play little role in the interference reducing effort.

2. As shown in Fig. 7, when the MS moves from BS1-1 to BS2-2 the interference level generating from BS2-2 to the MS increases, then the MS selects a pilot from the class that will be orthogonal to the pilot pattern allocated for BS2-2 and simultaneously it makes a handover process to switch the pilot from one class into another class to reduce the possible interference level.

3. When the MS moves from BS1-1 to BS3-3, as shown in Fig. 8, the interference level generating from BS3-3 increases, then the MS needs to select the pilot pattern from the class that is orthogonal to the pilot pattern allocated to BS3-3 and simultaneously it makes the handover process to switch the pilot from one class into another class to reduce the interference level.

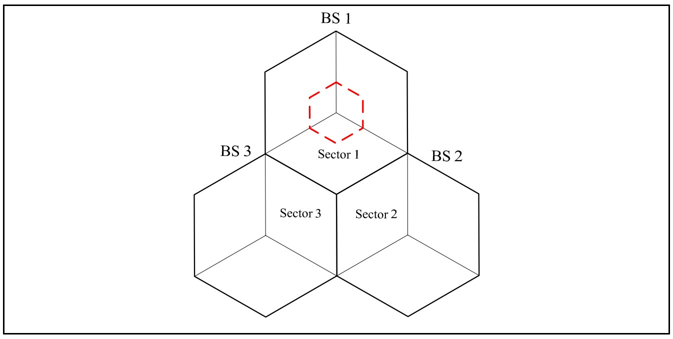

Figure 6 The MS is located in the Central of a Cell, its Distances are Far Away from other BSs; its Resulting Interference Level is Low

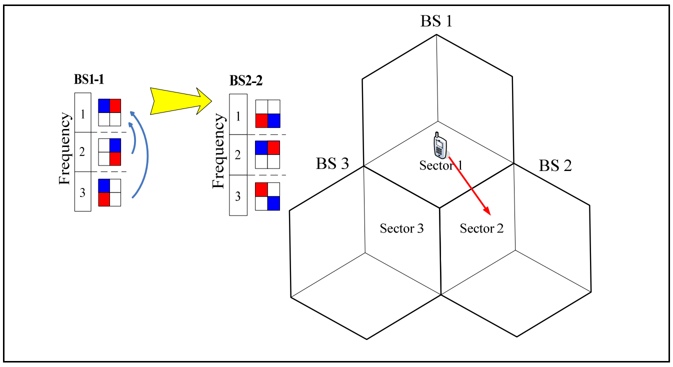

Figure 7 The MS moves from BS1-1 to BS2-2 it selects its Pilot from the Class that is Orthogonal to the Pilot of BS2-2

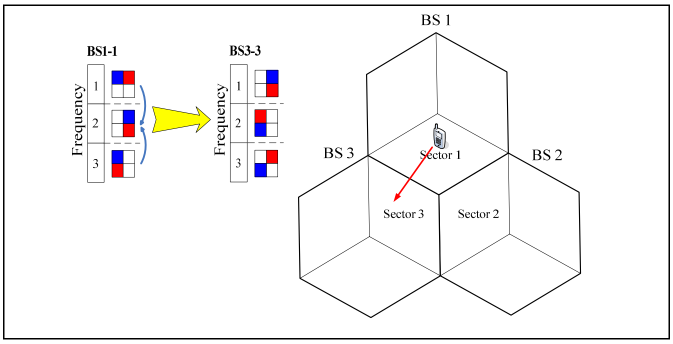

Figure 8 The MS moves from BS1-1 to BS3-3 it selects its Pilot Pattern from the Class that is Orthogonal to the Pilot of BS3-3

Similarly whichever the direction the MS moves, it is advisable to follow the pilot selection algorithm that a new pilot is selected to have it orthogonal to the existing pilots that are allocated to other BSs to reduce the resulting interference level. Although the theoretical optimal pilot selection principle is still not available in the literatures, however, we still can follow our design principle as discussed above in the selection of pilots so that its resulting interference level will be smaller than that generating from the conventional pilot design rule where all BSs are allocated with the same pilot having the result as shown in Table III.

TABLE III THE RESULTING SIGNAL STRENGTH BETWEEN THE MS AND BSS WHEN MOBILE MOVES AND DIFFERENT PILOTS ARE ASSIGNED FOR VARIOUS BS SECTORS

BS1-1	BS2-2	BS3-3	Sensitivity (dBm) MS: BS1-1 Interference: BS2-2 & BS3-3	Sensitivity (dBm) MS: BS2-2 Interference: BS1-1 & BS3-3	Sensitivity (dBm) MS: BS3-3 Interference: BS1-1 & BS2-2
Frequency 1	Frequency 1	Frequency 1	-134.2606	-134.2606	-131.2503
Frequency 2	Frequency 2	Frequency 2	-134.2606	-131.2503	-134.2606
Frequency 3	Frequency 3	Frequency 3	-131.2503	-134.2606	-134.2606

4 CONCLUSION

The pilot allocation principle to reduce the system interference level is proposed and studied in this paper. When a mobile moves from one BS into another BS its pilot allocation is switched so that the new assigned pilot to the BS will be orthogonal to the pilots allocated to the coming BSs to ensure a constant system interference level can be maintained no matter the mobile is stationary or moving in any directions. From the simulation results of considering various interference classes or scenarios it is evident that the resulting system interference level by using our pilot design algorithm is always lower than that generating from the conventional pilot design where the same pilot is assigned to all BS sectors.

ACKNOWLEDGMENT

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REFERENCE

[1] Sungeun Lee, Kyungchul Kwak, Jihyung Kim, and Daesik Hong, "Channel estimation approach with variable pilot density to mitigate interference over time-selective cellular OFDM systems, "IEEE Transactions on Wireless Communications, July 2008; pp. 2694-2704.

[2] Wenjun Wang, Xiaoguang Wu, , and Guixia Kang," Pilot Sequence Design Scheme for Inter-Cell Interference Mitigation in OFDM Systems under Time-Varying Channels," IEEE Vehicular Technology Conference, May 2008, pp. 314 - 318.

[3] H. Hijazi, Ros, L.," Polynomial Estimation of Time-Varying Multipath Gains With Intercarrier Interference

Mitigation in OFDM Systems," IEEE Transactions on Vehicular Technology, Jan 2009, pp. 140 - 151.

[4] Hsiao-chun Wu, Xiaozhou Huang, Yiyan Wu and Xianbin Wang, " Theoretical studies and efficient algorithm of semi-blind ICI equalization for OFDM," IEEE Transactions on Wireless Communications, October 2008, pp. 3791 – 3798.

[5] Osseiran, Afif; Guey and Jiann-Ching, " Hopping pilot pattern for interference mitigation in OFDM," IEEE 19th International Symposium on Personal Indoor and Mobile Radio Communications, Sept 2008, pp. 1 - 5.

[6] Recommendation ITU-R M.687, International Mobile Telecommunications-2000 (IMT-2000)

[7] Recommendation ITU-R M.1225, "Guidelines for evaluation of radio transmission technologies for IMT-2000",1997

[8] G. Calcev, D. Chizhik, B. Goransson, S. Howard, H. Huang, A. Kogiantis, A. F. Molisch, A. L. Moustakas, D. Reed and H. Xu, " A wideband spatial channel model for system-wide simulations," IEEE Trans. Vehicular Technology, Vol. 56, pp.389-403, 2007/11/26

[9] Daniel S. Baum et al, " An interim channel model for beyond -3G systems- Extending the 3GPP spatial channel modle (SCM)", Proc. IEEE VTC'05, Stockholm, Sweden, May 2005.

[10] C802.16m-07_122r2, "Email Traffic Model," IEEE 802.16 Broadband Wireless Access Working Group.

[11] "Digital mobile radio towards future generation systems:, COST Action 231 Final Report, EUR 18957

[12] V. Erceg, K.V.S. Hari, M.S. Smith, D.S. Baum et al, " Channel models for fixed wireless applications", Contribution IEEE 802.16.3c-01/29r4, July 17, 2001

[13] IST-WINNER II Deliverable D1.1.1 V1.0, "WINNER II Interim channel models", December 2006.