Time Varying Channel Estimation for Amplify-and-Forward Relay Network

M. F. Rabbi[1], Yusnita Rahayu[2] and Kamarul Hawari Ghazali[3]
Department of Electrical and Electronics Engineering
University Malaysia Pahang
[1]fzrabbi@gmail.com, [2]yusnita@ump.edu.my, [3]kamarul@ump.edu.my

***Abstract*- For high Doppler spread channel scenario, in this paper, we develop a channel estimation method for Orthogonal Frequency Division Multiple Access (OFDMA) based Amplify-and-Forward (AF) relay network. Specifically, using Basis Expansion Model (BEM) the fast time varying channels in Source-Relay and Relay-Destination links are approximated. Then a Least Square (LS) and a Linear MMSE (LMMSE) based algorithm is applied to estimate BEM coefficients which are used for channel reconstruction later. Then, we simulate some practical cases of user mobility. Simulation results indicate that the proposed estimators perform consistently in high Doppler spread scenario.**

***Keywords*- AF Relay, OFDMA, Channel estimation**

I. INTRODUCTION

In the evolution of mobile communication industries, innovation of Multiple-Input-Multiple-Output (MIMO) system was a great achievement to provide spatial diversity and to enhance the capacity of the network. However, this technology has become an extra burden for the next generation wireless communication for its complexity, size limitation of Mobile Station (MS) as well as the cost ineffectiveness. The alternative technology has been searched by many researchers focusing on the diversity. Current investigations in [1, 2] show that utilizing the cooperative nature of different users in the network, it is possible to get the user diversity to enhance network capacity as well as the flexibility on the network coverage. In this consequence, cooperative diversity scheme in relay network has become a popular candidate for the next generation wireless communication systems [3].

One of the major problems of the cooperative network is the channel condition between the MS-Relay Station (RS) is different from that of RS-Base Station (BS) link. So it is hard for the receiver to estimate the overall channel unless RS is given either some intelligence to estimate the MS-RS channel link or the Channel State Information (CSI) is fed back to RS [4]. The relay nodes can simply amplify the received signals before forwarding to the destination is known as AF relaying. Also relays would decode the signal and then forward to the destination is known to be Decode-and-Forward (DF) relaying. However the AF relaying requires less processing burden on the RS which may be another MS in the network. In this paper we consider the AF relaying to amplify and forward the source node signal to destination. OFDMA uplink system in such network consists of different users of different Carrier Frequency Offset (CFO) due to high Doppler frequency. Apparently these CFOs may destroy the orthogonal nature among subcarriers and cause Inter Carrier Interference (ICI) and Multiple Access Interference (MAI) [5]. Consequently, the channel estimation is crucial in this type of mobile communication environment.

Recently, the channel estimation in the AF relay network using OFDMA system has been given a lot of attention for the advantage of user diversity. However, most of the studies consider the channel state information is known at the receiver which is actually impractical. In [6] a novel training sequence based channel estimation scheme is proposed which is not incorporated with OFDM system. [7] has proposed another algorithm to estimate channel for AF relay network in OFDM system. [8] has also investigated the channel estimation for single relay assisted cooperative diversity systems where pilot insertion time is decreased with increment of Doppler frequency to get favorable performance. [9] has investigated the frequency offset estimation for OFDMA uplink utilizing the cooperative transmission provided the channel information should be fed back from the BS to MS. Similar feedback technique was used in [4] to get the best channel information between source and destination. However, all of the above studies focus on the time invariant channel which may not work for the current wireless technology such as IEEE 802.16-2012 [3] where high user mobility has been considered as an issue to design the physical layer (PHY).

In this paper, considering the high mobility of the user and/or relay station we develop a pilot symbol assisted channel estimation scheme for OFDMA uplink system in AF relay network. More specifically, in addition to a LS estimator we develop a LMMSE based channel estimator and compare their performances in practical high Doppler spread scenarios using simulation.

II. SYSTEM MODEL

We consider an OFDMA uplink system of U users with N subcarriers. Using Basis Expansion Model (BEM) in [13, 14] the time varying channel can be expressed as a linear combination of the Fourier bases and BEM coefficients. For a discrete time system as given by

$$h(n,l)=\sum_{q=-Q}^{Q} a_q(l)\exp\left(\frac{j2\pi nq}{gN}\right), 0\le n\le N-1, 0\le l\le L-1, \quad (1)$$

where $a_q(l)$ is the q-th BEM coefficient for l-th path and q determines the sampling resolution in Doppler domain. Note that g is the oversampling index and the relation between g and q can be shown as

$$f_q=\frac{q}{gT}, -\lceil gf_{\max}T\rceil\le q\le\lceil gf_{\max}T\rceil, \quad (2)$$

where f_q and $f_{\max}$ are the q-th sampled and maximum Doppler frequency respectively. With T being the OFDMA block period, it is possible to approximate the channel for a