Multiple Symbol Double Differential Transmission for Amplify-and-Forward Cooperative Diversity Networks in Time-Varying Channel

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***Abstract*— In the cooperative diversity wireless networks, the task to perform cooperation communication amongst neighbouring nodes is very challenging. Subjected to rapidly increasing mobility of the nodes i.e. wireless devices in fast moving vehicles and trains, at the destination end the receiver may not ideally estimate the channel characteristics and frequency offsets. Due to these circumstances which results in time-varying channels, the performance network degrades drastically. In order to enhance the performance in such environment, Double Differential (DD) modulation employing multiple symbol based detection is proposed which takes mobility environment of different nodes into consideration. By utilizing the DD transmission approach, the channel properties and frequency offset estimation is omitted in the amplify-and-forward cooperative networks. The MATLAB simulation and numerical analysis on Bit Error Rate (BER) are carried out with consideration on considering flat-fading (i.e. the frequency non-selective) Rayleigh channels and when frequency offsets. The results depict that the proposed method over fading channels without channel estimation requirements and in the presence of frequency offsets performs better as compared to the conventional DD transmission. Optimized power allocation is also carried out to enhance the network performance by minimizing the BER analytical expression. It is demonstrated that the proposed power allocation scheme offers enhancement over the equally distributed power allocation approach.**

***Index Terms*— Double Differential Transmission; Frequency Offsets; Multiple-Symbol Differential Detection; Sphere Decoding.**

I. INTRODUCTION

Cooperative or relay communications are an active area of research and have been widely explored in wireless communication systems. In cooperative communications, users exploit the broadcast characteristic of the wireless channel by cooperating among each other to transmit messages. Owing to its capability to provide untethered connectivity, coverage enhancement, throughput and mobile access, this technology has been studied and integrated into many modern wireless applications, such as cognitive radio and has progressed toward the next generation wireless communication standards, such as Long Term Evolution Advanced (LTE-A), WiMAX IEEE 802.16j and IEEE 802.11s. Accordingly, transmission reliability and high throughput will be a strong demand to support the high speed communication systems (e.g. mobile users in high speed rail system). Yet, in real-world wireless networks, the performance of the networks is greatly influenced by the channel fading and the mobility of the users.

In general, majority of the existing literatures assume that the relay(s) and destination channel coefficients knowledge are perfectly estimated (i.e. coherent detection). But, it is a difficult as well as challenging task for the nodes to estimate the channel perfectly in practice, particularly in time-varying environment due to the variation effects of the communication channels. Thus, non-coherent detection is introduced by exploiting the benefits of bypassing channel knowledge in the networks or in circumstances for which the channel knowledge is inaccessible. Single Differential (SD) transmission scheme is investigated in [1–4] and these schemes, the channel is fixed for at least two symbol periods. However, in the presence of frequency offsets the channel is unable to maintain fixed over the two symbol periods because of the mismatch of the source and receiver oscillator or relative movement among the nodes in time-varying channel and as a result the networks' performance is affected substantially [5]. There are two noteworthy methods to overcome the effect of frequency offset in the wireless communication channels.

One way to deal with the effect of frequency offset is to design excellent estimators that estimate and then compensate for the frequency offset as investigated in [5–9]. These schemes, however, increase the computational complexity and reduce the data rates transmission due to the use of extra pilot symbols that act as the reference in the estimation process. Hence, numerous studies on Double Differential (DD) modulation for Differential Amplify-and-Forward (DAF) in [4,10,11,12] and piecewise linear decoder for Differential Decode-and-Forward (DDF) in [14] are suggested, due to its attractive characteristic which is insensitive to frequency offset. Therefore, the estimation of frequency offset is not required at the destination. The detection employing DD transmission can be achieved by using the previously received symbols without requiring the accurate channel knowledge. Cano et al. in [5] demonstrated that the DD modulation is performed at the relays where a simple heuristic detector is designed in the distributive network using diagonal space-time (ST) unitary codes. The said scheme, however, requires the knowledge of the previous source. In addition the transmission ordering protocol (i.e. the protocol that determine the ordering of the nodes, such as which nodes acts as online transmitters, the first node source in the network nodes order and the destination node) is also required so that the source acknowledges the corresponding relay[15]. As the result, the scheme may be ineffective in an ad-hoc network as the moving node may joins or terminates from the network [5].