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Efficient relay selection scheme using regenerative and degenerative protocols for 5th generation WiMAX systems

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ABSTRACT

The major concerns for the 5th generation wireless systems are to provide higher data rates and higher transmission quality in the wireless network environment. Cooperative relaying as a promising technology has widespread attention, since it can achieve higher transmission quality and throughput for wireless networks. This paper aims at maximizing throughput and transmission quality by minimizing frame error rate (FER) as minimum as possible. Relay selection is an effective technique to improve the system performance in wireless networks by allowing users to cooperate with each other in their transmissions to achieve high transmission quality and diversity. This paper proposes an efficient relay selection scheme for WiMAX network with selection combining technique using amplify and forward and decode and forward protocols by analyzing the FER. FER approximation model based on improved signal to noise ratio was developed. In the proposed relay model, signals at the receiver are combined using selection combining technique. In maximum ratio combining (MRC) based cooperative relay systems, only the correctly detected signal will be forwarded by the relay and the performance will be worse under poor channel conditions. So the relay selection is done with selection combining technique. Simulation results exhibit the effectiveness of two relaying protocols amplify and forward (AF) and decode and forward (DF) individually and at high signal to noise ratio (SNR) region FER has been reduced in DF protocol than AF protocol. Based on the suppression of noise and effective retrieval of information, DF protocol is found to be more effective compared to AF protocol. The proposed structure is evaluated using performance parameters such as FER and SNR. Structural realization and analysis pertaining to Power and Throughput are implemented in MATLAB. Power allocation for water filling, optimal and sub optimal algorithms are analyzed for various channels. Simulation results have proven that suboptimal algorithm performs closer to optimal algorithm and water filling power allocation scheme outperforms both optimal and suboptimal scheme. High throughput is obtained by reducing the FER in DF protocol compared to AF protocol that improves the transmission quality of WiMAX networks. A throughput greater than 9.5 Gbps can be achieved using DF protocol which increases the speed of 5G network up to 10 Gbps.

1. Introduction

Cooperative diversity is the promising technique to achieve high data rate and high throughput in wireless networks. Users can relay information to exploit cooperative diversity, thereby increasing reliability and reducing power consumption in 5G WiMAX networks. Network with power managed scheme would achieve a better throughput performance and lower transmit power than a network without such schemes. WiMAX is a preferred fourth generation technology because it offers a clear path to the next generation. 5G is more about providing the services to people's need at the appropriate quality of service. Virtual multiple antennas can be formed to synthesize a virtual array that effectively emulates the operation of a multi antenna transceiver by the cooperative diversity technique, in which the source nodes cooperate with all other nodes in the wireless network [1–3]. The Shannon capacity region is enlarged for the fading channels when the channel state information (CSI) is available at the source nodes by the cooperative diversity and also high robustness against noisy channel is achieved. There are two well-known protocols in cooperative diversity namely amplify and forward (AF) and decode and forward (DF). In AF relay network, the relay amplifies the received information from the source which also contains noise due to multipath fading

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and forward to the destination. The capacity of the destination can be reduced due to noise amplification whereas in DF relay network, the information can be decoded to reduce the noise and then forwarded to the destination. Thus a reliable transmission of information takes place from the source to destination by decoding the message whereas the incoming noise signal will not be amplified. Hence the maximum capacity and accurate symbol estimation is achieved by DF relay network [4–8].

Relay selection is an important technique to achieve high transmission quality from source to destination and to achieve high diversity order equal to the number of relays is extensively studied in literature. The best relay is selected in the available set of relays to provide strongest end-to-end channel that represents an efficient bandwidth scheme [9]. In [12], relay selection was proposed to achieve maximum system throughput by effectively saving the total power consumed by the cooperative networks and by combining the signals from relays in an efficient manner. A best relay can be selected to forward the information from the source to destination to achieve diversity gain. By reduced the time slots required to complete the transmission from source to destination was achieved by selecting the best relay that transmits the source information efficiently was discussed in [11–17,22]. For multi relay networks, [4] proposes a relay selection scheme to search for a set of relays in the first phase which decodes the source information efficiently and then the best relay is chosen for transmission in the second phase. Relay selection scheme proposed by [6] is based on the harmonic mean of signal to noise ratio in the channel between source to relay and from relay to destination. For multi relay networks, relay selection based on DF relaying is proposed to avoid the error detection method used at relay nodes and also the feedback information required by the source with closed loop implementation. The CSI is provided through a feed forward channel from the relay to destination. Full diversity can be obtained by the relay selection method through the performance analysis of symbol error rate [17]. The best relay can be determined depending on the minimum or harmonic mean of signal to noise ratio from the source to relay and from relay to destination. Relay selection scheme proposed by [10] indicates maximum SNR achieved by relay to destination link. Relay selection scheme based on DF protocol with transmission scheme derived by the upper bound on the pairwise error probability of the maximum likelihood (ML) decoder is analyzed in [18]. Relay selection based on threshold value has been proposed in [19], in which the relays having SNR value larger than the threshold value are made to transmit. Due to the transmission of information in orthogonal channels by the source and the relays in cooperative diversity, there is a loss in spectral efficiency. Relay selection scheme proposed in [20] selects a single best relay which requires only two orthogonal channels for retransmission of information to the destination. Diversity gain can be realized on the order of number of relays in the cooperative network by selecting the best relay which provides the best path from the source to destination. Max–Min relay selection protocol has been analyzed in Rayleigh fading channels in terms of outage probability when the interference is present in relays and in destination. Relay selection in DF relay protocol, AF relay protocol is studied in Rayleigh fading channels [21]. An asymptotic bound for adaptive cooperative coding (ACC) protocol based on suboptimal power allocation under different channel propagation conditions were studied [23]. The optimal joint bandwidth and power allocation schemes were derived to maximize the sum capacity of all the users, maximize the capacity of the worst user and to minimize the total power consumption of all the users by using convex optimization techniques [24]. AF MIMO relay system using greedy minimum mean square error (MMSE) antenna selection algorithm was discussed in [26]. A closed form expression for the Mean square Error (MSE) was derived by adding additional antenna pair. In [27], the problems of joint transmit diversity selection and relay selection (RS) are expressed as MSE and mutual information (MI) joint discrete optimization problems and solved using iterative discrete stochastic algorithms.

In this paper, the initial phase focuses on analysis of relay selection based on DF relay protocol to study their end-to-end performance in terms of FER and throughput. At first relay selection in AF relay network is analyzed in terms of FER. Then DF relay protocol is analyzed. The DF protocol has reduced FER with increased throughput compared to AF protocol. From the comparison of FER in AF and DF protocol, relay selection is found to be the best in DF protocol. In the next phase power allocation for different algorithms are performed. Power allocated to different channels are analyzed for optimal, suboptimal and water filling algorithms. Based on the amount of power allocated to the channels, the traditional water filling algorithm proves to be the best over other two algorithms.

The remaining part of the paper is organized as follows: Section 2 depicts the system model description, Section 3 describes the concepts of power allocation, Section 4 deals with the mobile multihop relay (MMR) networks in WiMAX system, Section 5 describes the results and discussion which evaluates the FER of amplify and forward relay network, decode and forward relay network, comparison of AF, DF protocols and comparison of optimal, suboptimal and water filling algorithms. Finally, conclusions are drawn in Section 6.

2. System model description

The challenges of 5G technique is to increase the maximum throughput with lower battery consumption, lower outage probability and to achieve high bit rates in larger portions of the network coverage area [30]. High throughput with low power consumption can be achieved by mobile multihop relay networks where relay nodes are deployed between source and destination nodes. Fig. 3 shows multiple relay dual hop network which has a source node, a destination node and multiple relays between source and destination node. Information is transmitted from source to relay in first hop and from relay it is transmitted to the destination in second hop. Commonly used protocols for relay network are AF and DF protocol [25].

2.1. Degenerative protocol (AF protocol)

The protocol architecture of AF protocol is shown in Fig. 1 which is purely analog. Amplify and forward protocol is also called as degenerative protocol. In degenerative system the relay terminals amplify the signal from the source terminals without any decoding. AF protocol receives the signal from the upstream node, amplifies the signal and forward the signal to the downstream nodes. A transmitting antenna converts the electrical signal to electromagnetic waves and the receiving antenna performs the reverse operation. Band pass filter (BPF) receives the desired filter components and removes the noisy components in the received signal. Low noise amplifier which is located in the front end of the radio receiver amplifies the weak signals. It captures a very low power, low voltage signal plus associated random noise which the antenna presents to it and amplifies the signal within the bandwidth of interest at which the radio frequency (RF) section can operate without being disturbed by thermal noise. A frequency synthesizer is a device capable of generating a set of given output frequencies with high accuracy and precision from single frequency. It is composed of phase locked loop (PLL) and voltage control oscillator (VCO). The output of the synthesizer creates mirror spectral components of the desired signal at low and high frequencies. BPF is placed next to