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BEST RELAY SELECTION METHOD FOR DETECT AND FORWARD AIDED COOPERATIVE WIRELESS NETWORK

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ABSTRACT

This paper proposes the best relay selection method for detect and forward relaying cooperative wireless network. A two hop relay scheme is analysed, which consists of the source node (SN), destination node (DN) and distributed relay node (RN). Spatial modulation (SM) is introduced in this paper which can provide antenna diversity gain and to achieve the bit error rate (BER) and higher data rate. More specifically SM divides the input bit stream into antenna index bit and amplitude-phase index bit which can provides low complexity and to achieve high data rate. This scheme selects the most appropriate number of bits to re-modulate from the relay node and reduces the modulation order. Different modulation techniques have been analyses to find the best diversity gain in the cooperative wireless communication system. Cooperative communication help to achieve the transmitter diversity for the system by provides virtual antenna path between transmitter and receiver. Power consumption is one of the main concerns in modern communication, so the best relay selection algorithm is proposed which can select suitable number of relays and to attain energy efficient communication.

Keywords: relay selection, wireless network, spatial modulation, cooperative.

1. INTRODUCTION

Recently, multi-hop cooperative relay networks have gained a lot of attention as they provide high data rate and meet the better coverage requirement beyond 3G mobile radio systems. Cooperative relay is a promising extension to relay network, where several relay node scan transmit to the same destination to yield diversity gain.

The wireless communication is mainly degraded with the path loss, fading and shadowing effects. System uses multiple antennas, RAKE [1] receiver to achieve the diversity gain and to compact with the fading effect. Cooperative communication is considered as the effective solution for the fading effect and to achieve the better channel capacity. Relay transmission help to achieve the throughput and data rate by virtual diversity gain. System cooperation also known as the broadcast nature of signal by providing the virtual antenna arrays through relay nodes. Thus, single antenna users can achieve the diversity gain by distributing relays.

Cooperative communication provides better quality of service (QoS) [2] at deep fade condition by the help of spatial modulation. Spatial modulation (SM) is an attractive MIMO modulation scheme. It is capable of dividing the transmitting bit into antenna index bit (AI) and amplitude phase index bit (AMP) to achieve the better gain and provides a new dimension to the source message [3].The system characteristic such as throughput of SM scheme is higher than that of space, time code (STC) [4]. The spatial modulated system can avoid inter channel interference by providing the MIMO aided system. SM is helping to restrict the number of active antennas and to reduce RF chain, which can reduce fading effect. Cooperative communication is proposed with detect and forward relaying mechanism. Amplifying and forward (AF) and detect and forward are the main relaying protocol used for the cooperative wireless networks [5-8].Many authors have presented cooperative communication strategies. This paper proposes energy efficient multiple relay selection algorithm for ad-hoc network.

The organization of the paper is as follows, Section 2 discuss about the detect and forward relaying technique. Section 3 presents best relay aided detect and forward relaying. Section 4 discusses about the matlab simulation. Section 5 is the conclusion where we validate our work for real life application.

2. COOPERATIVE DeF SM SCHEME

This section describes the cooperative detect and forward relaying as shown in the Figure-1. The system consists of two hop relay network (source node (SN), relay node (RN), and the destination node (DN)). Multiple antennas can be placed in the RN. However, due to the physical limitation system considering the single antenna at the RN. The system consist of multiple (N_t) Antennas at the source and Nr antenna at the destination node. Here multi-aided relay node can also be considered and relay switching action [10] can be performed. The input bits are spatially modulated(SM) by the help of N_t transmitting antennas. Let's assume that the source node is transmitting the spatial modulated symbol to the RN and DN as $X_S(i) = [X_1(i), \ldots. X_u(i) \ldots\ldots. X_U(i)]$ where 'i' is given astrans mission block index. The SM modulated symbol consists of the AI-bits as well as APM-bits which was efficiently coded and transmitted to both relay node and the destination node. Let'C' denotes the complex field set. Then the transmitted SM symbol $X_u(i) \in C^{N_t \times 1}$ is given as $Xu(i) = S_l^q e_q$ [3], Where S_l^q is the APM modulated symbol transmitted from the q^{th}trans- mitting antennae.$e_q$is representing the active number of antennas in SM. It is representing $e_q \in C^{N_t \times 1} \left(1 \le q \le N_t\right)$.For an example, the L-QAM spatially modulated system is having N_t transmitted antennas and the total symbol in SM scheme is represented as $M_{all} = \log(l.N_t)$.

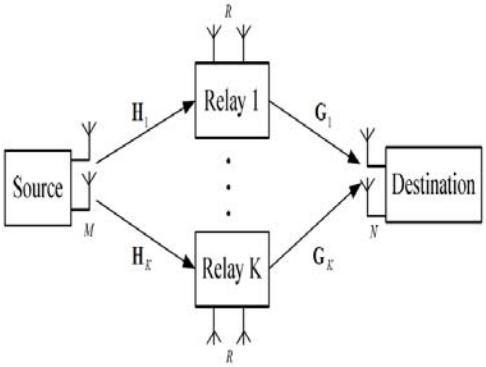

Figure-1. System model of the cooperative DeF-aided SM scheme.

Figure-1 shows the generalised method for cooperative spatial modulation. The signal received at both the RN and DN is given by

$$Y_{SR}(i) = H_{SR}(i) X_S(i) + N_{R(i)} \quad (1)$$

$$Y_{SD}(i) = H_{SD}(i) X_S(i) + N_{D(i)} \quad (2)$$

Here $H_{SR}$and H_{SD} are channel characteristics having the [12] Complex valued random Gaussian distribution $CN(0,\sigma^2{}_{SD})$ and $CN(0,\sigma^2{}_{SR})$ respectively. The N_D and N_R are the noise components of the DN and RN has the Gaussian distribution with 0 mean and noise variance N0.

During the cooperative scheme, if the relay detected any error in the transmitting symbol from the SN itretransmit the corresponding bits from the SN. Otherwise, if relay flawlessly detected the transmitted symbol, then it re- modulate the signal with an L-QAM modulation and forward to the DN. Relay performance is depended on the number of antennas used in the RN and due to the physical limitation here we are considering only one antenna at the RN but more than one relay is executing for the DeF relay technique. By considering the detection importance of the AI and APM-bits [13], different detection methodology is analysed. Here we have analysed and compared the partial detect and forward relaying strategy for improving the RN efficiency. Partial DeF relaying is based on the AI and APM bits and RN will transmit either antenna index bit or the amplitude and phase index bit to the destination. So this partial detect and forward (p-DeF) method makes two scenarios at the RN [14].

Having generated the symbol after the DeF [10] method,$X_{RD}$is transmitting bits to the DN node. The received symbol at the destination is represented by

$$Y_{RD}(i) = H_{RD}(i) X_{RD}(i) + N_{RD}(i) \quad (3)$$

Where H_{RD} is the channel gain characteristics of the relay to destination path and it has given as a standard Gaussian distribution with $CN(0,\sigma^2{}_N)$ .N_{RD}, an additive white Gaussian Noise with zero mean and N$_o$ as the noise variance. In the DeF relaying scheme implement the Simplified Joint ML Detection at the DN. The DN is detecting the signal from the SN (2) and the RN (5), in order to get better cooperative relaying strategy. In [13] single stream maximal likelihood detection is defined. Here we are extending the result of the multiple relay selection method for the $N_r$antennas at the destination. Our joint DeF-SM scheme will combine the signal From Different relay as well as from the direct path; this estimated AI and APM bit are represented by

$$\mathrm{Y(i)} = \begin{bmatrix} Y_{SD} \\ Y_{RD} \end{bmatrix} \in C^{(N_r+1)\times 1}$$

$$= H(i) X(i) + N(i) \quad (4)$$

Where H is the combined channel gain factor and is represented by the identity matrix form with both sources to relay path and relay to destination path. The corresponding matrix representation is given by

$$H(i) = \begin{pmatrix} H_{SD}(i) & 0 \\ 0 & H_{RD}(i) \end{pmatrix} \quad (5)$$

Where X(i) is the combined signal from the SN and RN.N(i) is a noise power component. In this paper, we have assumed that both relay and destination node are well aware with the channel state information and the system is performed under additive white Gaussian noise having zero mean and constant variance. The signal received at the destination from source (Direct path) and relay are represented in matrix form as

$$X(i) = \begin{bmatrix} X_S(i) \\ X_{RD}(i) \end{bmatrix} \quad (6)$$

$$N(i) = \begin{bmatrix} N_D(i) \\ N_{RD}(i) \end{bmatrix} \quad (7)$$

Then, at the detection [14], DeF-SM detection can be formulated as

$$(\hat{q},\hat{l}) = \arg\min \left\{ \left\| \hat{y}(i) - H(i) X^{(q,l)}(i) \right\|^2 \right\} \quad (8)$$

$$= \arg\min \left\{ \left\| Y_{SD}(i) - H_{SD}(i) X_S{}^{(q,l)}(i) \right\|^2 + \left\| Y_{RD}(i) - H_{RD}(i) \mathrm{X}_{RD}{}^{(q,l)}(i) \right\|^2 \right\}$$

Where

$$X^{\square (q,l)}(i) = \begin{bmatrix} X_S{}^{(q,l)}(i) \\ X_{RD}{}^{(q,l)}(i) \end{bmatrix} \quad (9)$$

And

$$X_S^{(q,l)}(i) = \left[0, 0, S_l^q, 0\right] \tag{10}$$

Here, S_l^q is given by the l^{th} constellation point on the transmission, and X_{RD} is representing the modulated symbol transmitted from the RN.The system performance of the multiple antennas placed at the DN can be explained by the mathematical expression

$$\text{BER} = {}^{2L-1}C_{L}\,\frac{1}{2^L}\left(\frac{1}{SNR}\right)^L \tag{11}$$

Which shows that the probability of bit error generated at the destination node is inversely depending on the L^{th} power of the signal to noise ratio, where L is the number of antennas used at the destination node DN.

I. Best relay selection technique

Here all relays assumed to be performed in time division multiple accesses and routed as orthogonal signals. With all relay participation, the available power is equally divided between 'M' relays. We are assuming that the ideal maximum ratio combining (MRC) has been used in the RN and DN. Hence the SNR at the destination node is the instantaneous sum of all relay nodes. The best relay selection method is represented in the Figure-2. The instantaneous SNR is represented as,

$$\gamma_i = \gamma_{S,D} + \sum_{i=1}^{M} \frac{\gamma_{S,i}\gamma_{i,D}}{1+\gamma_{S,i}+\gamma_{i,D}} \tag{12}$$

$$\gamma_{S,i} = |H_{S,i}|^2 \frac{E_s}{N_0} \tag{13}$$

$$\gamma_{i,D} = |H_{i,D}|^2 \frac{E_s}{N_0} \tag{14}$$

$$\gamma_{S,D} = |H_{S,D}|^2 \frac{E_s}{N_0} \tag{15}$$

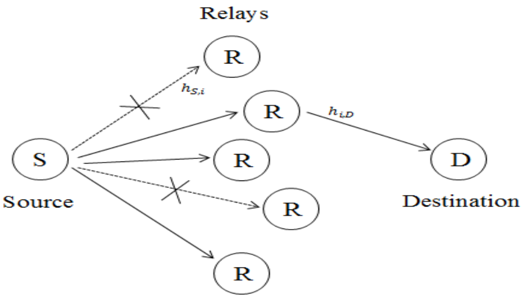

Figure-2. System model for best relay cooperative scheme.

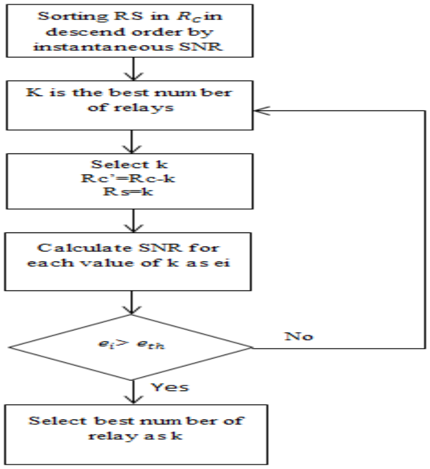

Figure-3. Procedure for energy efficient relay selection.

Where, $\gamma_{S,i}$, $\gamma_{S,D}$ and $\gamma_{i,D}$ are the instantaneous signal to noise ratio of source to relay, source to destination and relay to the destination link respectively. Here the best relay selection algorithm is proposed, which will select the best relay path at which signal can attain maximum SNR. During the first hop, source node has transmitted the information to the best selected relay based on the instantaneous SNR and in the second hop the destination node will select the appropriate number of relays among the selected relay set. The first step is related to identifying the weakest path among the relay, which will determine the number of relays required for acquiring promising data rate in the cooperative communication. The best relay selection criteria is given on the basis of SNR as

$$a_i = \max_{i\in A}\{\min(\gamma_{S,i}, \gamma_{i,D})\} \tag{16}$$

Where A= {1,2.... M} and γ_i is the instantaneous SNR of the relay i. Here the system will maximize the minimum SNR of relay and attain suitable communication path. Based on the SNR value, system will select the suitable number of RN for the energy efficient relaying scheme. Figure-2 shows the best relay selection algorithm, where a suitable number of relays select and route the signal. Figure-3 shows the procedure to select the best number of relays where ‘e’ represented the system capacity for different number of relay channels. Here we have calculated the capacity of the relay system as

$$e_i = \max\ e_{sk} = \sum_{j=1}^{k} \log\left(1 + \frac{p_{sj}}{N_0}\right) \tag{17}$$

Where p_{sj} is calculated by the water filling algorithm, and $\sum_{j=1}^{k} p_{sj} = p_s$ is the total transmitting power. Here Rc is the total number of relay nodes and Rs is the selected relay from the k number of relays. In the best relay algorithm, we have selected each relay node and check the corresponding channel capacity to the threshold capacity level for the best relay selection algorithm. In the initial stage Rc=Rc’=k as total number of relays and Rs=Rs’=0. Then based on the channel capacity we have selected the best number of relay nodes k’ so that Rc’=Rc-k’ and Rs’=k’, where we get maximal channel capacity and best reception characteristics.

3. SIMULATION RESULTS

In this section performance technique of detecting and forwarding cooperative scheme with best relay selection method is analysed. In Figure-4 the SNR performance of cooperative communication with Maximal likelihood detector is analysed. The figure shows the performance of the system with different equalization techniques. The ML detection mainly compared with the maximal ratio combining technique and the spectral improvement is also shown here. The simulated result compares with theoretical result and is showing that simulated result for ML detection matching with theoretical result. Here, two different relaying schemes, namely amplifying and forward and detect and forward based relaying scheme are compared in this section. Reconsidering the concept of detect and forward relaying scheme, forwards the data if and only if the cyclic redundant check-based error detection does not spot any errors in the signal received at the RN. In other way, the amplify and forward scheme forwards the data regardless of the presence or absence of detection errors, which may lead to error propagation effects through the RN. Here system added the numerical upper bound for this simulation derived on the basis of [14]. From the simulation result it is shown that the non-cooperative scheme shows the performance measure, which is very poor than the cooperative relay aided technique at ML detection method. The plot also showed the simulation output for detect and forward relaying mechanism with conventional amplify and forward technique. By comparing the numerical result of the DeF scheme with ML detection, which is defined in the ‘Furuzan’ paper [4], our DEF based scheme is showing the best performance, nearly 5dB improvement in the constant BER of 10^{-4}. The simulation shows that for a fixed gain of 15dB, the cooperative relaying method improves the bit error rate almost 62% than the non-cooperative system. Considering a constant gain of 15dB, Figure-5 shown the characteristics of different relaying strategies achieving the performance of 8dB gain at the SNR=10^-5. Here output plot by considering relay node and destination node well known about the channel state information. This paper compared the error ratio of conventional spatial modulation which is defined in the paper ‘spatial modulation’ by ‘malesh’ [5], with detects and forward aided cooperative network. Simulation illustrates the error probability graph of efficient relay mechanism, where best number of relays is considered for the improvement in signal reception. The simulation shows that, when number of relay nodes increases then performance of cooperative relay scheme shows the BER improvement. From the output graph it has concluded that when we use multiple relay nodes in the communication then system can achieve better BER performance.

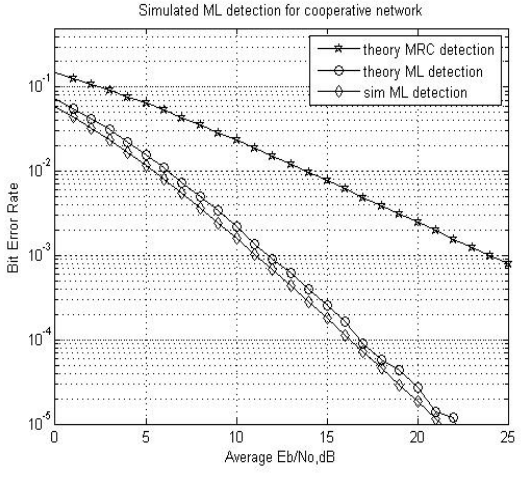

Figure-4. System model for ML detection.

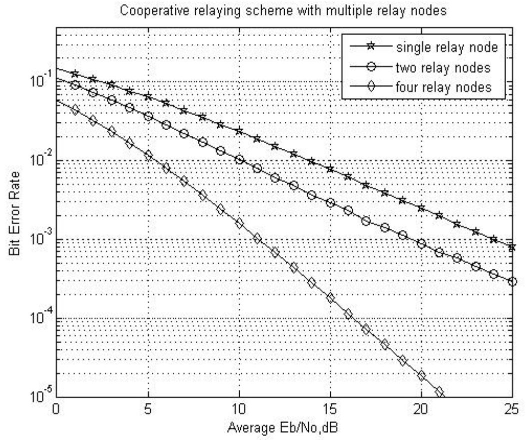

Figure-5. Multiple relay nodes for cooperative network.

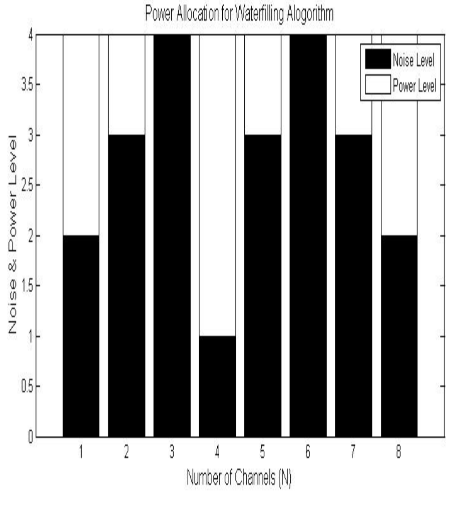

Figure-6. Water filling algorithm.

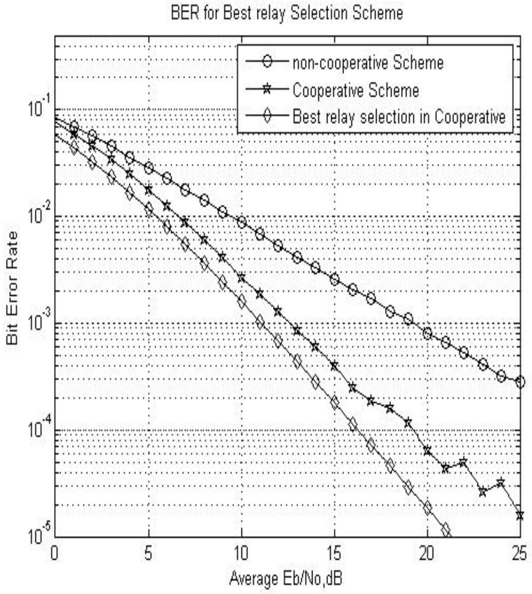

Figure-7. Best relay selection for cooperative communication.

Figure-6 shows the conventional water filling algorithm where transmitting power is compensated with respect to the channel noise ratio. The source node will transmit the information on account of instantaneous noise ratio. Here water filling algorithm is proposed in which most appropriate amount of input power is allocated with respect to the attenuator factor. The simulation output shows that the input power is reallocated with respect to mean noise component of the channel. The variable power level is allocated for the input source signal in accordance to the noise margin. In this paper we have considered a constant power margin and input power is arranged with respect to that power with the help of water filling algorithm. Maximum power level is adjusted as 4w for analysis. The simulation results verify our conclusions that when SNR is sufficiently small, relay number increases linearly with the ratio of the antennas of source and destination; when signal to noise ratio is sufficiently large, relay number increases exponentially. When R/ Nis larger than 3, Kbecome extremely large. As K is finite in relay system, optimal relay capacity may not be achievable, which will make some capacity loss of the first hop network.

Figure-7 shows the output performance graph for best relay selection algorithm, in best relay selection mechanism power distributed according to the water filling algorithm. The best relay selection helps to improve the data rate as well as energy consumption in the wireless communication.

4. CONCLUSIONS

In this paper, we are proposing energy efficient best relay selection method for detect and forward aided cooperative relay network. This paper analyses two-hop multi relay system to assume that minimum threshold level is known to the relay and destination. We proposed the relay selection algorithm which will select the suitable number of relays on the basis of instantaneous channel fading factors. SNR of each relay is calculated and protocol tried to maximize the minimum error ratio to attain the ideal SNR ratio. The proposed system also defined the spatial modulated based detect and forward relaying strategy, which can out performed conventional amplify and forward relaying scheme. The proposed scheme has also allowed implementing the multiple relay hoping strategy which further improves the system characteristics than conventional communication methods. We are comparing the existing protocol with our proposed scheme. Although our numerical analysis has assumed simplified technology, through simulations, we have verified the compatibility of best relay selection technology for general scenarios.

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