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A Novel Approach of Relay Selection using AF & DF Relaying Techniques

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Abstract – **The paper looks at the performance comparison of different detection schemes and also proposes how to group users at the relay to ensure mutual benefit for the cooperating users. This research work proposes a framework which shows single and multiple relay selection using amplify & forward and decoded & forward relaying techniques under Rayleigh fading environment for cooperative communication.**

Keywords –**AF, Cooperative Communication, DF, MIMO, MRC, Relay Selection, SC.**

I. Introduction

Increased demand for wireless communications applications has generated a significant development of wireless networks, in particular several generations of cellular networks in voice and data resources. The radio equipment and wireless services evolve to become more efficient and less costly for its users. Thanks to the work and studies of researchers and experts who understand the environment of the transmission channel and generally multi-user communications. By cons, compared to wired communications, we begin to understand the fundamental performance limits of wireless networks and practical methods to approach. Moreover, given their growing impact in society, the wireless communications remain an important research topic.

The cooperative communication is an interim solution. It proposes to share the antennas of neighbouring nodes to create this diversity. By having a knowledge of the state of the channel, the nodes will lend each other antennas transmitting packets from their neighbours on higher quality channels. This and promising technique can not only circumvent the problems of unstable channels but also increase link capacity. Historically, cooperatives techniques appeared at the physical layer and many proposals have been made in this direction. However, in the upper layers, the inclusion of these cooperatives techniques is still a subject on which many studies must be conducted [1, 2 and 3].

The fundamental standard of cooperative communication is utilizing other communication devices to relay transmission. The source node broadcasts information to both the relay node and the destination node. The relay node then advances the transmission to the destination node. The source node views the transfer node as a virtual antenna, empowering MIMO frameworks to be utilized without adding physical antenna.

By utilizing the cooperative communication technique, the source node can discover relay nodes which have worthy channels to the destination node, use it to relay the transmission to the destination node, and expanding the dependability of the entire transmission. By selecting relay nodes nearer to it, the source node can likewise spare battery power, since it does not need to transmit at high power and can utilize the relay devices' energy to accomplish the transmission.

Since the source node in the cooperative communication technique relies on upon the relay nodes to forward the transmission, relay selection for the relay nodes get to be vital with a specific end goal to acquire ideal execution of the cooperative communication framework. By picking the right nodes to relay the transmission, the framework can accomplish higher capacity by utilizing lower assets. Previous work done on the relay selection for cooperative communication can be found in [4-10].

The main objective of this paper is to implement a framework which shows single and multiple relay selection using amplify & forward and decode & forward relaying techniques under Rayleigh fading environment for cooperative communication.

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II. PROPOSED METHODOLOGY

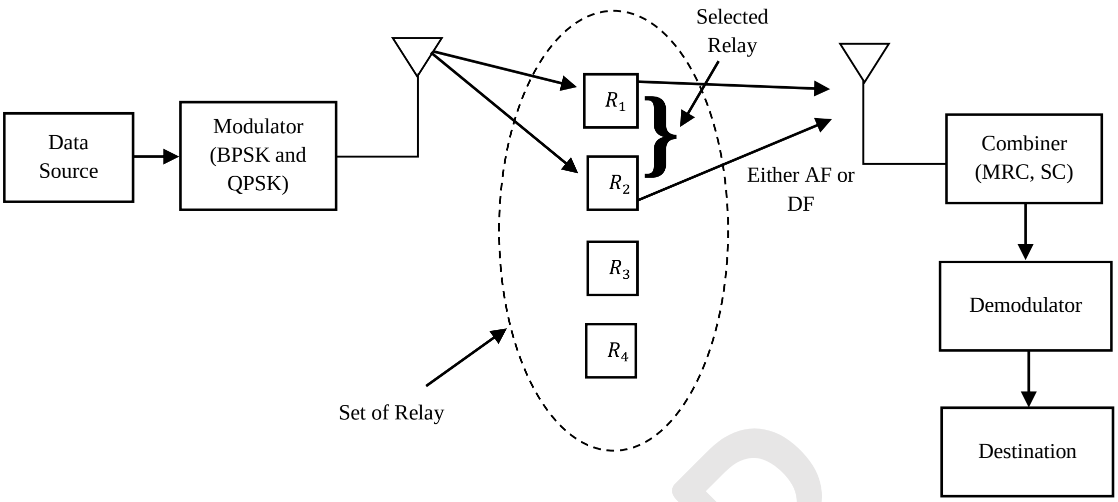

Figure 1: Block diagram for proposed method

Figure 1 shows the basic block diagram for proposed approach. It contains data source, BPSK modulator, QPSK modulator, combiner, demodulator and a set of relays. Data source generates a signal which is further modulated by BPSK modulator and transmitted to different relays. Rest of the process is explained in the following headings.

Modulation

Modulation is the technique by which the signal wave is transformed in order to send it over the communication channel in order to minimize the effect of noise. This is done in order to ensure that the received data can be demodulated to give back the original data. BPSK modulation technique is used in this research work.

Relaying

There are several cooperative relaying techniques depending on how the relay processes the information. In this research work, we have used two relaying protocols:

- Amplify and Forward (A & F)
- Decode and Forward (D & F)

Amplify and Forward (A&F)

It represents the simplest method among the several cooperative techniques and is a non-regenerative relay. Information is sent to the relay through a noisy channel, where it is amplified and forwarded to the destination without further processing. In cooperating Amplify and Forward system, symmetric transmission exists between source and relay.

The source transmitted signal $X_{si}(l)$, the relay transmitted signal $X_{ri}(l)$. Source transmitted signal $X_{si}(l)$ to the destination and it is overhead by the relay as $y_{si,d}(l)$

$$y_{s_i,d}(l) = \sqrt{\varepsilon} h_{s_i d} X_{si}(l) + \eta_{s_i d}(l) \quad (1)$$

Where l=1,2,……..L_1,$L_1$is denoted as length of the first segment. In the second segment, the relay amplifies its overhead signal $y_{s_i r_i}(l)$

$$y_{s_i r_i}(l) = \sqrt{\varepsilon} h_{s_i r_i} x_{s_i r_i} + \eta_{s_i r_i}(l) \quad (2)$$

Where l=1,2,………L_2,L_2 denoted as length of the second segment using maximum likelihood detection method

$$X^1{}_{ri}(l) = \beta y_{s_i r_i}(l) \quad (3)$$

$X^1{}_{ri}(l)$is denoted as transmitted to the destination through relay.

Where $\beta = \sqrt{\frac{1}{\left|h_{s_i r_i}\right|^2 \varepsilon + N_0, s_i, r_i}}$, $X^1{}_{ri}(l)$ will be transmitted to the destination through relay uplink channel as:

$$y^1{}_{r_i,d}(l) = \sqrt{\varepsilon} h_{r_i d} X_{r_i}(l) + \eta_{r_i d}(l) \quad (4)$$

Where l=1,2……L_2 is indices the length of the second segment signal and $L_1 = L_2$ After the two segments, the destination will be combine the received signal $y_{s_i,d}(l)$ and $y^1{}_{r_i,d}(l)$

Using the Z-F and MMSE detection:

$$r_{s_i,d}(l) = \frac{h^*_{s_i d}\sqrt{\varepsilon}}{N_{0 s_i d}} y_{s_i,d} + \frac{h^*_{r_i d}\ \beta\, h^*_{s_i r_i}\sqrt{\varepsilon}}{\left|h_{r_i d}\right|^2 \beta^2 N_{0,s_i r_i} + N_{0,r_i d}} \quad (5)$$

$r_{s_i,d}(l)$ is further passed to a decoder in to retrieve source information. The energy symbol (ε) which is normalized in channel nodes p and q. They change independently from (two segment) process yielding a slow fading channel $n_{pq}(l)$ denoted by the additive noise which is modeled as a zero mean, mutually independent complex Gaussian sequence with

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variance $N_{0,pq}$. For channel between nodes p and q if the instantaneous channel received signal to noise ratio (SNR) is:

$$\gamma_{pq} = \frac{|h_{pq}|^2 \varepsilon}{N_{0,pq}} \qquad (6)$$

The average channel received SNR between nodes p, q expressed as:

$$\overline{\gamma_{pq}} = \frac{E\left[|h_{ij}|^2\right]\varepsilon}{N_{0,pq}} \qquad (7)$$

If source and relay have similar uplink channel quality as $\overline{\gamma_{s_i d}} = \overline{\gamma_{r_i d}}$, the system is defined as having symmetric up links. If $\overline{\gamma_{s_i d}} \neq \overline{\gamma_{r_i d}}$ the system is defined as having asymmetric uplinks.

Decode and Forward (D&F)

In this case, the relay is regenerative, because it receives the information from the source and decodes that before retransmitting it to the destination. Decode and forward transmission, the appropriate channel model is for cooperative diversity transmission, we model the channel during the first half of the block is:

$$y_{s_i r_i}(l) = h_{s_i r_i} x_{s_i}(l) + \eta_{r_i}(l) \qquad (8)$$

If $l = 1 \ldots \frac{L}{4}$ where $x_{s_i}(l)$ is the source transmitted signal and $y_{r_i}(l)$ is the relay signal. The second half block, we model the received signal

$$y_{s_i d}(l) = h_{r_{j,d}} x_{r_j}(l) + \eta_d(l) \qquad (9)$$

The source mobile transmits its information as $x_{s_i}(l)$, l=0 . . .$\frac{L}{4}$ during this interval the relay process $y_{r_i}(l)$ by decoding an estimate $x'_{s_i}(l)$ of the source transmitted signal. The relay transmits the signal $x_{r_i}(l) = x'_{s_i}\left(l - \frac{L}{4}\right)$ for l=$\frac{L}{\Delta+1}$- - -- -,$\frac{L}{2}$

This research work uses two combining schemes:

- Selection Combining
- Maximal Ratio Combining

Selection Combining

In selection combining, the signal with the largest instantaneous SNR is chosen as the output. Let K represents the number of incoming signals then out of K signals, the one with maximum instantaneous SNR is selected.

Maximal Ratio Combining (MRC)

Selection combining scheme does not achieve diversity gains since it uses only one branch with maximum instantaneous SNR but MRC scheme removes this drawback by combining input signals in all diversity branches. MRC scheme is considered to be optimal in case of AWGN noise because it has the ability to boost instantaneous output SNR.

Assume a system with N_d diversity branches, the instantaneous output SNR is given by:

$$SNR = \left(\frac{E_b}{N_0}\right) \frac{\left|\sum_{i=1}^{N_d} \mu_i \beta_i e^{j\theta_i}\right|^2}{\left|\sum_{i=1}^{N_d} \mu_i\right|^2} \qquad (10)$$

Where E_b is bit energy; N_0 is noise spectral density, μ_i is the combining weight and β_i and θ_i are the magnitude and phase of the received signal respectively.

To obtain the maximum instantaneous output SNR, Cauchy-Schwarz inequality is applied, giving the maximum value as:

$$SNR \leq \left(\frac{E_b}{N_0}\right) \frac{\left|\sum_{i=1}^{N_d} \mu_i\right|^2 \left|\sum_{i=1}^{N_d} \beta_i e^{j\theta_i}\right|^2}{\left|\sum_{i=1}^{N_d} \mu_i\right|^2}$$
$$= \left(\frac{E_b}{N_0}\right) \sum_{i=1}^{N_d} \beta^2{}_i = \sum_{i=1}^{N_d} SNR_i \qquad (11)$$

The only condition to reach this maximum value is to set:

$$\mu_i = c\beta_i e^{-j\theta_i} \text{ for } i = 1,2, \ldots . N_d \qquad (12)$$

Where c is some arbitrary complex constant. Therefore, according to (12), in MRC, the magnitude of the combining weight is proportional to the magnitude of the received signal, and the phase of the combining weight is the negative value of the phase of the received signal.

The maximum SNR in equation (11) also suggests that MRC can create an output in the form of SNR equivalent to the total of the individual SNRs in every assorted diversity branch. It takes after that MRC can suggest the benefit of delivering an adequate outcome; SNR nevertheless when none of the SNR in particular branches is satisfactory.

III. Simulation Results

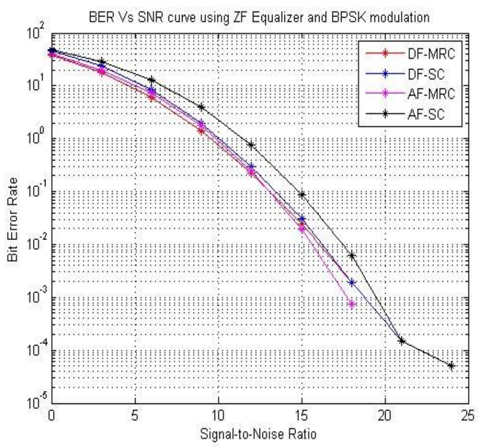

Figure 2: Comparative analysis for BER performance of DF-MRC, DF-SC, AF-MRC and AF-SC with Zero Forcing equalizer in BPSK modulation

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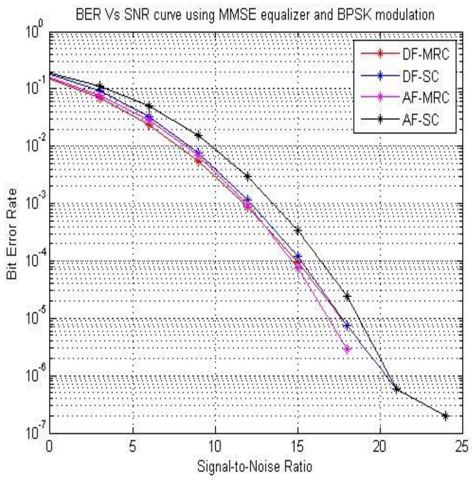

Figure 3: Comparative analysis for BER performance of DF-MRC, DF-SC, AF-MRC and AF-SC with MMSE equalizer in BPSK modulation

IV. CONCLUSION

The proper selection of the relay can effectively improve the overall performance of the network in terms of higher data rate, lower power consumption and better bit error rate performance. This research work utilized ZF and MMSE equalization techniques with BPSK modulation. For combining, it uses maximal ratio combining and selection combining. Simulation results show that the multiple relay selection performs better than the single relay selection in terms of evaluation parameters; BER, SNR.

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