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REVIEW ARTICLE

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A SURVEY ON GREEN MULTI-HOP COOPERATIVE COMMUNICATION

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ABSTRACT

Energy efficiency is the main issue in wireless communication. The cooperative communication is a technique to reduce the energy consumption in wireless networks and to make the wireless system environment friendly. Moreover, cooperative communication with multiple relay nodes is also capable of reducing the effect of fading and to improve the performance of wireless network using diversity techniques. In this paper a review on green multi hop cooperative communication with signal space diversity technique is discussed.

Key Words: Green Communication, Energy Efficiency, Co-operative Communication, Diversity.

I. INTRODUCTION

For developing power efficient communication we need to optimize the power usage in wireless communication systems. Power hungry applications tend to rapidly dissipate energy in the mobile devices. The future systems are expected to be always connected supporting higher data rates and multiple radios. That will also requiring more and more power. With the motivation of saving power in wireless systems many research issues are required to be addressed [1]. In a typical wireless communication environment so many obstacles in transmission path are there. Due to this transmitted signal will be faded. To avoid the increment in fading the transmitting power is increased which leads to waste of energy. To overcome the effect of fading we use diversity. The advantage of multiple inputs multiple outputs (MIMO) system is becoming popular. MIMO system is more energy efficient than traditional SISO systems in Rayleigh fading, but MIMO techniques require complex transceiver circuitry. These complex circuits consume more power for signal processing in MIMO. More antennas implementation at a single node is not physically possible and the solution of this problem is cooperative MIMO [2]. For this, cooperative communication is introduced. Multiple virtual antennas are used in cooperative communication This implementation not requires complex circuits. Moreover, it provides low energy consumption in virtual MIMO cooperative networks [3]. In cooperative communication, source node (user) broadcasts the signal to many relays and then signal is retransmitted with or without amplification to another node. For signal retransmission Amplify and Forward (AF) or Decode and Forward (DF) modes are used. Decode and Forward technique has the advantage because it does not amplify the unwanted noise signal. When the path loss increases in transmission each node transmits with same power as that of a direct transmission source. So performance of system improves with increasing the number of hops [4-5]. This multi-hop transmission is continuously performed before the signal reaches at the destination node. DF protocol also improves the bit error rate performance of multi-hop communication over the fading channel [6]. To improve the performance of multi-hop cooperative communication Signal Space Diversity (SSD) is also used. Using SSD in cooperative communication, not require any extra power and bandwidth for signal transmission [7, 8, 9]. SSD also improves the performance over the fading channel [8]. So, cooperative communication with multi hop is capable to provide good quality of services even in the presence of fading. It also increases the coverage area in the shadow [10]. It is shown in [11] that Green Multi-hop Cooperative Communication (GMCC) gives the better performance and reduces the energy consumption in wireless communication network. By proper relay selection method, GMCC improves the performance of systems.

II. GREEN COMMUNICATION

In all over the world wireless mobile broadband communication networks are contributing to global energy consumption. Up to now, more works are reported for improving wireless networks coverage and capacity with required quality of services requested by users at the low cost. This results in increased per subscriber's data rate and additional base stations. However energy efficiency ia another important aspect. Energy efficient enhancement requires mechanisms to use at all levels of communication systems. Several investigations are being carried out in this research area, to reduce the energy consumption. Several stages of communication systems are being used to reduce the power use by antenna and energy consumption of base station [12-13]. Cooperative communication is energy efficient technique in which source transmits the signal on node to node basis to reduce the transmitted energy consumption.

A. Cooperative communication : The cooperative communication is based on relaying nodes, has emerged as a promising approach to increase spectral and power efficiency. This node mediator between the source and destination increases the network coverage area. Cooperative communication with MIMO systems is very efficient network systems. Similarly to multiple antennas transceivers, relays provide diversity by having multiple replicas of the signal of interest. By properly coordinating different nodes, virtual antenna array can be realized. This results in increased overall quality of the wireless transmission, in terms of energy efficiency and network capacity. Since cooperative MIMO system consumes less energy so it categories in green communication. We now review main cooperative signaling methods [14].

(a) Amplify and Forward (AF): This is a simple cooperative signaling method based on amplify and forward. In this each user receives a noisy version of the signal and then amplifies it and resends the signal. After receiving this signal, destination combines these to get proper message signal. The main problem with this technique is that, it also amplifies the unwanted noisy signals.

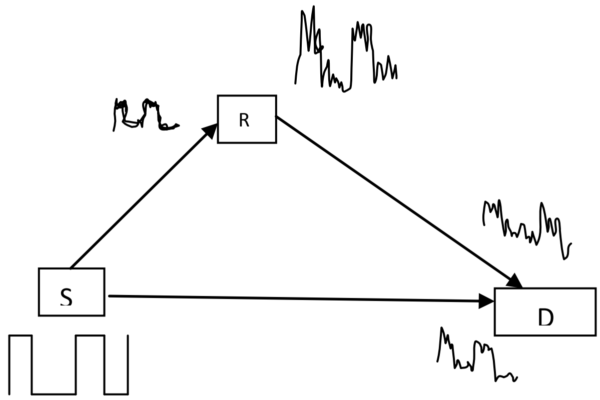

Figure 1.Amplify and Forward protocol

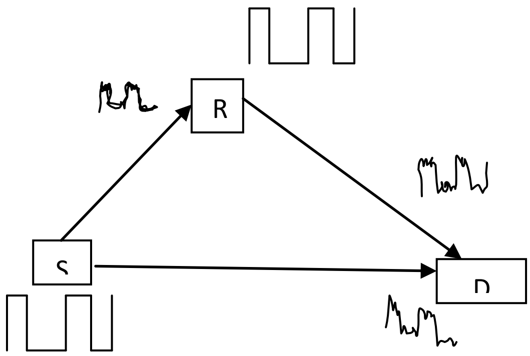

Figure 2.Decode and Forward protocol.

(b) Decode and Forward (DF) Method: In this scheme, relay node regenerates the message signal which is received by the source. Relay node receives the signal from the source or another relay node. After that node re-encode the signal and then retransmit it. In DF protocol scheme, data processing at each node takes time resulting in delayed transmission. Since relay node is established between the source and destination, transmitted power will be reduced. At each relay node copy of message signal is generated, so this method improves the Bit Error Rate (BER) performance of the systems. It requires the intelligence device at relay node for generation of copy of message signal.

B. Diversity : In a typical wireless communication system, there are various obstacles between source and destination. Due to these obstacles multiple transmission paths will exist, hence multiple copies of signal reached at the receiver. These multiple copies of message signal have attenuation, delay, distortion, interference and phase shift. Attenuation in amplitude due to destructive interference is called the fading. In mobile communication, multiple path signals are present time varying channel. In fading environment it is difficult to recover the message signal at the destination. So it is necessary to reduce the effect of fading in wireless communication. Diversity is the technique used in wireless communication systems to improve the performance over a fading radio channel. In diversity, receiver is provided with multiple copies of the same message signal which are transmitted over two or more real or virtual communication channels. Thus the basic idea of diversity combines all the copies of message signal and by these copies, generates the desired message signal.

(a) Frequency Diversity : One approach to achieve this diversity is to modulate the information signal through different carrier's frequencies. Each carrier should be separated from the others by at least the coherence bandwidth (Δf) so that different copies of the signal experience different fading. At the receiver, independently faded copies are combined to give a statistic for decision. The combiner combines the all the signals and generate the appropriate desired information signal. Frequency diversity can be used to combat frequency selective fading. Figure 3 shows signal s(t) is transmitted at different frequencies. The frequency difference Δf is used to avoid the frequency interference. Frequency selective fading is very useful in moving source or moving relay node. But this technique requires more transmitted power and stable frequency oscillators.

(b) Time Diversity : Another technique to achieve diversity is to transmit the desired signal in T different periods of time, i.e., each symbol is transmitted at the intervals of T times. The intervals between transmissions of the same symbol should be at least the coherence time so that different copies of the same symbol undergo independent fading. Optimal combining can also be obtained with the maximum ratio combiner. Figure 4 shows the signal s(t) is transmitted at the interval of Δt for avoid the overlapping.

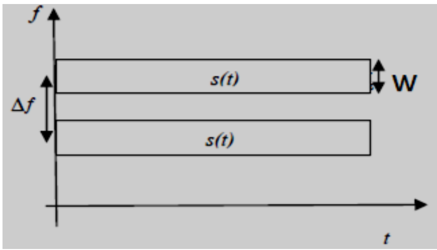

Figure 3.Frequiecy diversity scheme.

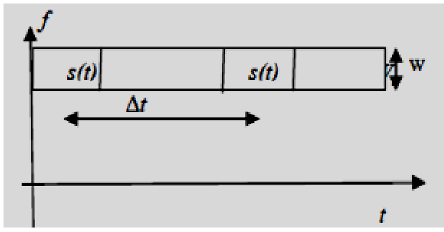

Figure 4.Time diversity scheme

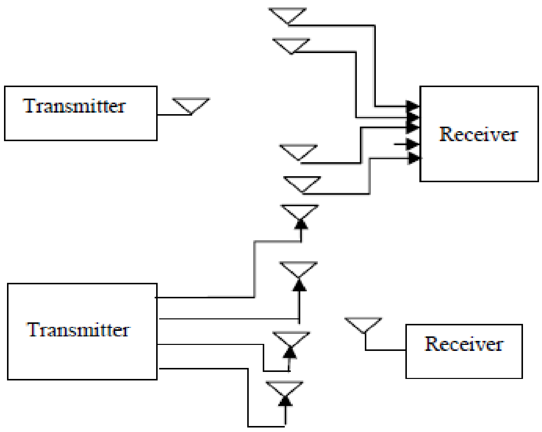

Figure 5.Signal Space Diversity

(c) Space Diversity : Another approach is to use multiple antennas to receive multiple copies of the transmitted signal. The antennas should be spaced far enough apart so that different received copies of the signal undergo independent fading. Implementation of space diversity requires no additional work at transmitter. It also not requires additional bandwidth or transmission time. Spatial diversity can be employed to combat both frequency selective fading and time selective fading. Receiver has the multiple copies of message signal so it is easy to recover the message signal in the presence of deep faded environments. Space diversity can be performed by single antenna at the transmitter side with multiple receiving antennas or also performed by multiple antennas at the transmitter with single antenna at the receiver side. Both of these techniques generate the multiple copies of message signal at the receiver so it improves the BER performance of wireless networks.

III. COOPERATIVE COMMUNICATION WITH SIGNAL SPACE DIVERSITY

This section represents green multi-hop cooperative communication scheme with signal space diversity, known as (GMSSC) [11]. SSD enables improvement in the system performance in fading channel conditions. The system uses decode and forward technique to achieve cooperative communication. Figure 6 shows the block diagram presentation of the system.

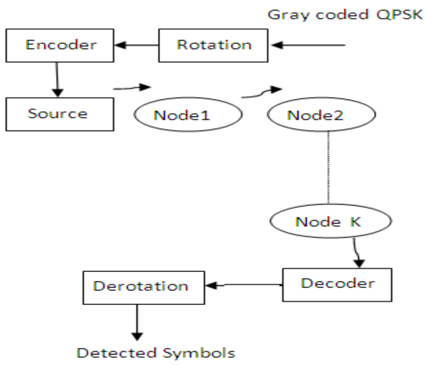

Figure 6. GMSSC System

There are K multiple relays present in the system with the implementation of signal space diversity. Fading is assumed to be Rayleigh. In GMCC schemes source transmits the message signal. Node is selected by applying node selection algorithm. Then the selected node receives the signal. This node contains the decoder and de-interleaver to generate the copy of message signal. Then again this regenerated signal transmitted by node to another node which is selected by selection algorithms. This transmission of signal continuously performed till the message signal reaches at destination.

IV PERFORMANCE ANALYSIS OF THE GMCC SCHEME

(a) Energy Analysis: Multi-hop wireless cooperative communication reduces the energy consumption. Source first transmits the signal to the nearest node. So it requires less energy for signal transmission in comparison with direct transmission from source to base station. Energy consumed by a node depends on energy required for per bit processing and for its transmission.

The total energy consumed per bit which includes both the transmission energy and the circuit energy is given by [2],

$$E_{bt} = \frac{P_t + P_s}{R_b} \qquad (1)$$

Where P_c is the power consumed by all circuit blocks, R_b is the bit rate, and Pt is the transmitted power is given as [2],

$$P_t = (1+\psi)E_b R_b \frac{(4\pi)^2 d^{\alpha}}{G_t G_r \lambda^2} M_I N_f \qquad (2)$$

With Ψ= (η/ξ)-1 where η is the drain efficiency of the RF power amplifier, and **ξ** is the peak to average power ratio which depends on the modulation scheme and the associated constellation size. E_b is the required energy per bit at the receiver for a given P_b requirement, M_l is the link margin compensating the hardware process variations and other additive background noise or interference, and N_f is the receiver noise figure defined as $\mathbf{N_f} = N_r / N_0$. N_0 is single-sided thermal noise power spectral density (PSD) at room temperature, and N_r is the PSD of the total effective noise at the receiver input.

Second term in equation (1) P_c is calculated by transmitter and receiver circuits. For this considering a general communication link connection between two wireless nodes, P_c is calculated as [2]

$$P_c = M_t(P_{DAC} + P_{mix} + P_{filt}) + 2P_{syn} + M_r(P_{LNA} + P_{mix} + P_{IFA} + P_{filt} + P_{ADC}) \quad (3)$$

Where P_{DAC}, P_{mix}, P_{filt}, P_{syn}, P_{LNA}, P_{IFA},P_{ADC} are power consumption of digital to analog converter (DAC), mixer, active filter at transmitter and receiver, frequency synthesizer low noise amplifier(LNA), intermediate frequency amplifier (IFA), analog to digital converter (ADC).

In cooperative communication signal is transmitted node to node and reached at destination. For a (K + 1) hop DF system with equidistantly spaced relays, the total energy consumed per bit E_{bt} can be approximated as [11]

$$E_{bt}' = \frac{(P_t/(K+1)) + (K+1)P_c}{R_b} \quad (4)$$

Since the signal is received and transmitted (K + 1) times, therefore the P_c of a single hop is multiplied by (K + 1), but P_t of a single hop is reduced by (K + 1) due to shorter length of the hops. Hence, an improved overall performance and energy efficiency is achieved in comparison to a single hop case. Also from equations it is clear that a multi-hop system is energy efficient i.e. $E'_{bt} < E_{bt}$ provided the condition $(K + 1) < (Pt/Pc)$ is satisfied.

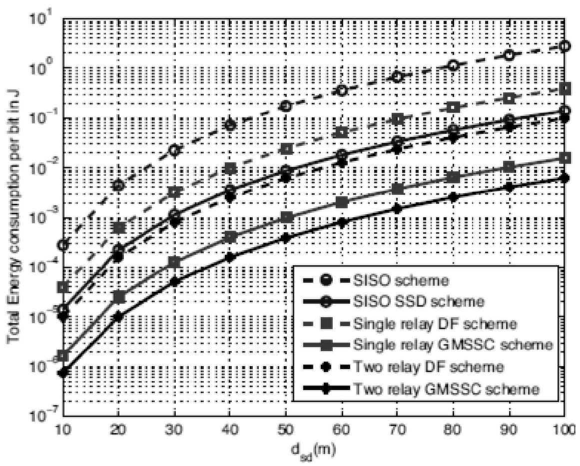

Figure.7 Comparison of total energy consumption per bit among various schemes

Figure 7 shows the reduction in energy consumption with distance as the number of nodes increases [11].

(b) BER Analysis: Figure 8 shows the BER performance of GMSSC system for different values of signal to noise ratio employing different number of relays. In all cases the performance of this system is quite better. The reason is the use of SSD, with optimized rotation of constellation points and interleaving.

V. CONCLUSION

In this paper different concepts of cooperative communication, protocols used in it and the techniques to improve the performance of cooperative communication are reviewed. It is found the decode and forward mode is widely used due to its advantages. A brief review of diversity techniques have been done, which are used to further enhance the performance of cooperative communication system. A recent scheme GMSSC has been thoroughly revived. This scheme uses rotated constellation of QPSK with interleaver to improve the BER performance of system. Further improvement in the system performance is achieved by SSD. Energy analysis of cooperative communication is also presented, with the help of which energy performance of any cooperative communication can be done. This reviewed literature can be the basis for enhanced cooperative communication system.

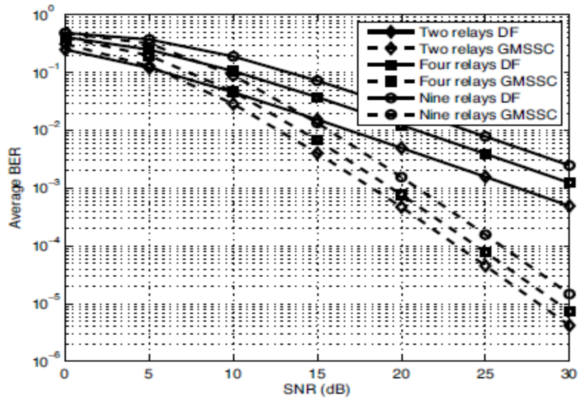

Figure.8 Comparison between GMSSC and traditional DF schemes for multiple relays

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