A Review of Relay selection based Cooperative Wireless Network for Capacity Enhancement

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Abstract - *Cooperative communication can be considered as a promising technology to significantly increase the transmission rate along with the coverage area of a wireless network which aims to achieve spatial diversity via the cooperation of user terminals in transmission without requiring installation of multiple transceiver antennas. The user terminals which can be used for this purpose can be termed as relay nodes. However, most of the existing solutions on relay node assignment problem with multiple source-destination pairs are limited to assign each single pair at most one cooperative relay node. Therefore, this paper studies the cooperative relay node assignment problem in a network environment, where multiple source-destination pairs compete for the same pool of cooperative relay nodes and each pair can be allotted multiple cooperative relay nodes for cooperative communication to maximize the transmission rate and hence improves the performance among all communicating pairs. Without requiring multiple antennas on the same device, spatial diversity is achieved by exploiting the antennas on other nodes, i.e., relay nodes, in the network. Therefore, the selection of relay nodes has a significant impact on the achieved total capacity.*

Key Words: Cooperative communication, MRC, DSTC, DTSBC, AF, DF etc...

1. INTRODUCTION

In the past decade, there has been a tremendous growth in the area of telecommunications. As cellular phones and the high speed Internet become more and more popular, the demand for faster and more efficient telecommunication systems has been skyrocketing. Both the increase in the number of users and the increase in high data rate transfers from the Internet have produced a huge increase in traffic. In order to handle this heavy traffic, the whole telecommunications infrastructure has been transformed in the past several years. Thousands and thousands of optical fibers were laid underground to allow high speed, wide bandwidth signal transfer. This has solved most of the problems for land-based systems. However, more and more high-speed services are now carried out in a mobile environment where data transfer is done through wireless channels. Compared to the capacity of a fiber, the capacity of a wireless link is the weakest part in the whole infrastructure. Many people have realized this and have tried different methods to increase the bandwidth of the wireless channels. Before going any further, let us explain how wireless communications systems work [1].

In most wireless communications systems, there are two major components - base stations and the mobiles. The base station is located at the center of a coverage area called a 'cell' and the mobiles can be anywhere within the cell. Communication then takes place between the base station and the mobile through the wireless channel. A certain amount of spectrum is assigned to a cell for signal transfer. This spectrum provides the media for the signals to be transmitted. With a wider spectrum, more users can be served within a cell. To serve a large area, one can use a high power base station to cover the whole area. But only a fixed amount of users can be served in this way. So instead of having a single large cell, multiple cells with smaller size are usually used to cover a large area. To avoid severe interference between cells, base stations that are adjacent to each other are allocated different spectrum or channel groups. Also the output power of the base station is maintained at a level so it is just enough to cover the whole area up to the cell boundary. With this method, cells that are separated by a certain amount of distance can use the same spectrum. This is true as long as the interference caused by surrounding co-channel cells is within tolerable limits. In this frequency reuse scheme, each cell in the cluster has one-seventh of the total spectrum, and the same spectrum is used in cells with the same label. With this cellular reuse method, the same spectrum can now be reused over and over again and can be used to cover an infinitely large area.

2. BACKGROUND

As mentioned earlier, Cooperative Communications help in improving the system reliability. Cooperative Diversity can be defined as a form of space diversity [9]. Some of the popular cooperatives techniques are Amplify and Forward and Decode and Forward [10-12]. In the former method, the relays receive the information, amplify the signal and forwards again to the destination, whereas in the later method, the relays completely decode the original signal, encode again and then transmit to the destination. Since the

relays also send the original signal, these methods are called repetition based cooperative algorithms. It is also clear that this method causes a decrease in bandwidth, as the nodes require separate channels within the limited bandwidth.
Distributive Space Time Coding (DSTC) [13] can be used to realize cooperative diversity to prevent the bandwidth limitations. As mentioned in [14], DSTBC is a distributed form of STBC i.e., a replica of the information is shared among the cooperating nodes for transmission. Since we are dealing with DSTBC and cooperative diversity, we consider a single relay system and emphasize these methods.

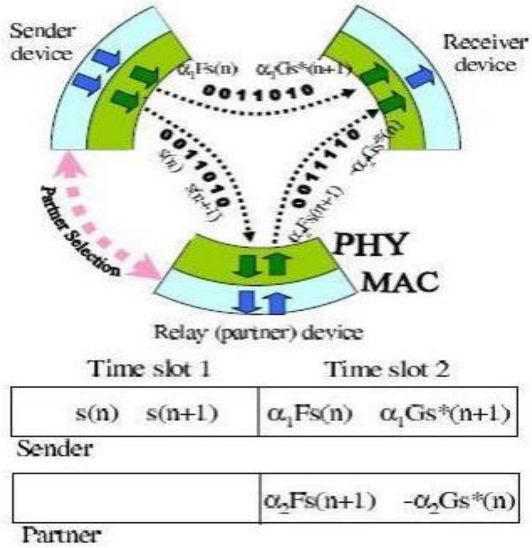

Fig. 1: Single channel based cooperative communication using DSTC [15]

A single channel based cooperative communication using DSTC is shown in fig 1. The system consists of a sender, a relay and a destination. During the first time slot, the transmitter sends two symbols, s(n) and s(n+1) to the relay (* denotes conjugate of the symbol, α_1 and α_2 are the real coefficients which are related as $\alpha_1^2 + \alpha_2^2 = 1$ [15], [16]). During the second time slot, the sender and relay cooperatively transmit the blocks. F and G are the coding matrices used to encode the signals. These space-time encoding matrices are orthogonal in nature. Hence they can be transmitted by the sender and relay at the same time and thereby improving the reliability of the communication as well [15].

2.1 Amplify and Forward

The standard method of communication is transmitting the information from sender to the receiver. In cooperative communication, the sender sends the same information to both relay and the receiver during the first time slot. In the next time slot, the destination receives another set of signals; one from the sender and the other is an amplified version of the signal in the first time slot. This amplified signal is transmitted by the relay. Now, the receiver can decode the combined signal using Maximum Ratio Combining (MRC). This can be performed with the help of a matched filter. The relay receives the information signal appended by the channel gain and noise.

It is then amplified and sent to the destination. The final information received is a combination of the input signal convolved with the channel gain and Additive White Gaussian Noise (AWGN). It is easy to implement because there is no possibility for errors while decoding which could be introduced in decode and forward. The major disadvantage of this method is that the noise will also be amplified at the relay. This can be eliminated by maintaining a high threshold level at the reception. Amplify and forward method is more advantageous than decode and forward method in achieving maximum diversity. Mathematically, it can be shown that, the outage probability is inversely proportional to the square of the Signal-to-Noise ratio (SNR). Hence, an increase of 10dB SNR can reduce the outage probability by an order of 100 [17].

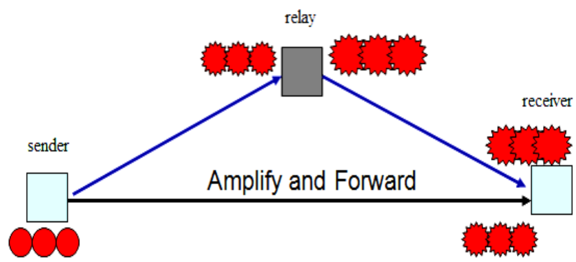

Fig.2: Schematic representation of Amplify and Forward [18]

2.2 Decode and Forward

In this method, the relay decodes the received signal from the sender, checks for errors and re-encodes to transmit to the destination. The receiver estimates the information signal using Maximum Ratio Combining. The relay can either decode the entire signal or it can perform symbol-by-symbol decoding [19]. When the relay decodes the received signal, the noise introduced in the information signal should be removed prior to decoding. Otherwise, it is more likely that the original signal could be corrupted.

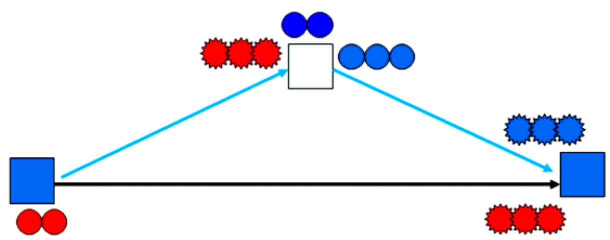

Fig.3: Schematic representation of Decode and Forward [18]

The destination must decode the signal completely. Hence the destination must be aware of both the decoding techniques in order to fully decode the signal. In real time environments, there is less certainty that the decoded signal sent from the relay would again be noise affected. Nicholas Laneman et. al. have shown in [17] that the decode and forward method fails to attain full spatial diversity. Mathematically, they proved that the outage probability is inversely proportional to the Signal-to-Noise ratio. i.e., the outage probability reduces at the same as the SNR rises.

3. CHALLENGES IN WIRELESS COMMUNICATION

A fundamental challenge of the wireless communication is the low reliability of the wireless channels. These pertain to the channel impairment due to multipath, fading, and shadowing, which is caused by receiving different versions of the source signal from different paths. The propagate paths result from scattering, reflection and diffraction of the transmitted signals by objects in the environment [2], such as buildings, trees, etc. Therefore, the capacity of a wireless channel has very high variability.

In addition to the unreliable channel, the spectrum resource over wireless channel is limited. Meanwhile, the required spectrum is increased as a consequence of high demand of high data rate services. Therefore, in order to reuse the frequency resource and satisfy the QoS requirements, the cellular coverage is restricted. Moreover, the increasing demand of high data rate transmission and the migration to high carrier frequency regions greatly limits the coverage of the wireless network. With the potential use of millimeter wave band in next generation wireless systems [3, 4], the cell size is reduced because by the Friis free-space equation, a millimeter wave signal experiences tens of dB more attenuation than a microwave signal. On other hand, to improve the transmission bit rate, more spectrums is required, and it also leads to coverage reduction. For instance, the coverage area has to reduce by 13 times, if the corresponding transmission bit rate rises by 100 times [5]. The natural method to address the coverage issue is to increase the number of the base stations in a region. However, it significantly raises the infrastructure cost.

Furthermore, energy consumption and environmental issue are caused by the fast growing data traffic volume and remarkable expansion of network infrastructures. From [6], approximately 18% of the Operation Expenditure results from the energy bill in the mature European market and at least 32% in India. Meanwhile, the enormous escalation of energy consumption due to the explosive development of wireless communications will directly result in the increase of greenhouse gas emission and becomes one of the major challenges in meeting the cost reduction and green environment targets [7].

Many techniques of wireless communications are emerging that suggest different architectures for the described problems above. Cooperative communications as an attractive alternative is suggested by the standard task group in IEEE 802.16j Mobile Multihop Relay to extend the coverage of a base station by deploying several relay stations around the base station [8].

4. PROPOSED WORK

Cooperative communications, shown in Figure 4, have recently become a key technology for the modern wireless networks as an effective means of saving power, attaining broader coverage range, and mitigating channel impairments resulting from fading. It has been incorporated into many wireless standards, such as 3GPP long-term evolution (LTE) [20-22], IEEE 802.11s (mesh networking) [23], IEEE 802.16j (wireless multihop relay) [19], IEEE 802.16m (WiMAX2) [24, 25] and Femtocell [26].

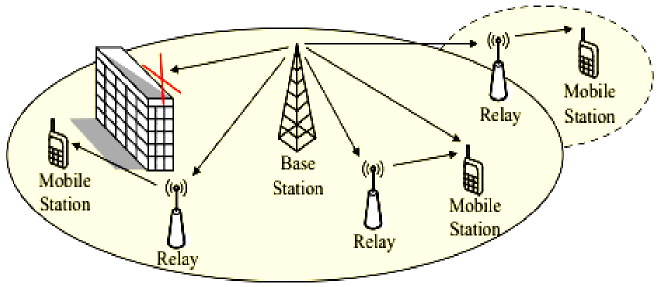

Fig. 4: Cooperative communications in a wireless network.

Relay communication, which is a specific kind of wireless cooperative communication, has been demonstrated to be an effective way to combat wireless fading by providing spatial diversity without the need of multi-antenna configurations [27]. The fundamental idea of relay communication is that several relay terminals participate in communications by retransmitting a signal from a source to a destination by forming a distributed multi-antenna system [28, 29]. Relaying mimics MIMO communications by establishing interactions among the distributed nodes that serve as virtual multiple antennas both at the transmitter and receiver sides. The final destination receives multiple versions of the transmitted signals through the cooperative relay nodes and combines them forming the final received signal. In relay systems, the received and retransmitted signals at any relay node are typically orthogonalized to avoid the interference.

It means the transmissions of source-relay and relay-destination are performed in different time slots or frequency bandwidths. The application of relays in cellular systems can permit economical design for the case that there is few or infrequent user at the edge of cellular. Since the relay does not need a wired connection to the backhaul, it can eliminate the costs of the backplane that serves as the interface between the BS and the wired backhaul network. Besides, relay communications will reduce the required transmit power compared to those for a base station (BS) due to the smaller coverage. Moreover, if the density of relays in a cell is moderately high, the propagation loss from the relay to a terminal is much lower than from a BS to the terminal. Thereby higher data rates can be achieved in larger cells [30].

Furthermore, multi-hop relay cooperation scheme is an attractive approach to solve the area coverage problem with a reasonable infrastructure cost. In a cellular, all idle users can act as relays to participate in the communication by establishing independent paths between the source and the destination. Hence, there is a potentially large number of relays which are able to help the base station to forward the signals. When the target mobile station is out of the service coverage of the base station, one or more relay node can retransmit the signals from the base station towards the destination. As a result, the coverage is substantially extended with the assist of relay nodes.

5. CONCLUSION

The Relay choice plays an important role in increasing the diversity gain achieved in wireless cooperative communication systems, and therefore it has mostly attracted attention of the many research teams over the past few years. Different relay choice schemes are designed with completely different focus and objectives. during this paper, we have a tendency to mentioned a literature survey on a number of the foremost representative areas of relay selection/assignment domain in cooperative networks on with varied types of relaying ways and techniques. Designing the reliable relay assignment scheme may be a principle working area in wireless cooperative networks. The implementation of the relay nodes with intelligence to perform some constant operations (such as compress, demodulate, amplify etc.) on the incoming signals and brings out the advantageous manipulations within their behaviour in the cooperative surroundings will become important research area. We also centered on the optimum relay assignment algorithm that provides the optimum answer to allocate the relay node for enhancing the capability. in an exceedingly later a part of the article, a ray of light on the MIMO technology shows the foregone conclusion of this technology within the area of cooperative communication in relaying network.

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