ASYMMETRIC DSFC CODED COOPERATIVE NETWORK

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Abstract: Distributed space frequency coding [DSFC] provide increased throughput in wireless communication. In this paper, a novel algorithm is proposed for asymmetric Distributed Space frequency coding. It is implemented at relay node for Decode and Forward [DAF] protocol. In asymmetric DSFC, the number of paths per fading channels is different. The asymmetric DSFC with direct link and without direct link with cyclic redundancy coding is designed and analyzed with the help of SER versus SNR performance and compares with existing system which had been implemented for symmetric DSFC. DSFC with direct link from base station to destination node is designed to improve the cooperative and frequency diversity.

Keywords: Decode-and-Forward, relay channels, space-frequency coding, Cooperative communications, diversity, OFDM

I. INTRODUCTION (HEADING 1)

In wireless services, the transmitted signal is affected by many channel impairments like shadowing, fading. This results into the degradation of the wireless system performance. To improve the system performance various diversities has been introduced. The diversity uses independent channels to deliver same signal with different samples. It has been proved that, spatial diversity improve the system performance by reducing the effect of channel impairments. Later cooperative diversity has been introduced, which uses relay to forward the information from base node to destination node. The performance is also depend upon the location of the mobile relay and the protocol used by the relay [1] [2].

Lately[3],various relaying protocols and several combining methods has been introduced to achieve diversity and to see their effect on the system performance, which include Decode And Forward [DAF] and Amplify and Forward protocol [AAF] [4]. In Decode and forward, the relay decodes the information, transmitted from base node, and then resend the decoded information to the destination node. In Amplify and forward protocol [AAF], the relay amplifies the information transmitted from the base node and then resend the information to the destination node. As the Decode and forward [DAF] decodes the information at relay, results in better performance than amplify and forward [AAF] at the relay, which amplifies the signal by a factor [5] [6]. This Cooperative communication concept improved the capacity, also increased the coverage of the wireless network [7].

As the number of relays increases the data rate loss increases [8]. Due to this, Distributed space time code [DSTC] is introduced to achieve the diversity over fading channels, frequency non selective channels [9] [10]. For multipath fading channel, Distributed Space Frequency coding [DSFC] is designed to achieve the frequency diversity over the channel. The Distributed Space Frequency Coding [DSFC] considered in paper [11], consist of base node to relay node path and relay node to destination node path. It does not consist of base node to destination node path, which can be used to recover the signal at the destination node. The signal from base node is transmitted to destination node over M paths, which also increases the diversity order of the system.

In paper [12], Distributed space frequency is designed to achieve the cooperative diversity. In paper [11], the cyclic redundancy code is used at relay to decode the information, and considered that not all relay will decode the correctly. The relay which decode correctly, that information will get forwarded to the destination node. Also, the number of paths between base node to relay node and relay node to destination node are same. In practical, the number of paths from base node to relay node and relay node to destination node are different.

In this paper, The Distributed Space Frequency Coding [DSFC] with Decode and forward [DAF] protocol at relay node is considered with a CRC code, in which the number of paths from base node to relay node and relay node to destination node are considered as same. This is Symmetric DSFC concept. In case of Asymmetric DSFC, number of paths from base node to relay node and relay node to destination node are different. These both cases are implemented with direct link and without direct link. This improves the diversity as well as flexibility of the wireless network.

The rest of the paper is organized by considering decode and forward protocol. In Section II, the system model and working of Symmetric Distributed Space Frequency Coding [S-DSFC] general model without direct link is presented. In Section III, Asymmetric DSFC [A-DSFC] without direct link is explained with the algorithm. In section IV, Symmetric DSFC and Asymmetric DSFC with direct link is explained with block diagram and algorithm. In section V, the simulation results of all these algorithms with DAF are presented. Finally, Section VI concludes the paper.

II. SYMMETRIC DSFC WITHOUT DIRECT LINK

A. System Model

Here, the distributed space frequency coding (DSFC) is considered to achieve diversity across the frequency axis for multipath fading channel [11]. Fig. 1 shows a general DSFC model, which is a two-hop relay model with OFDM modulation with K subcarriers. The base node to relay node and relay node to destination node channels are multipath fading channels.

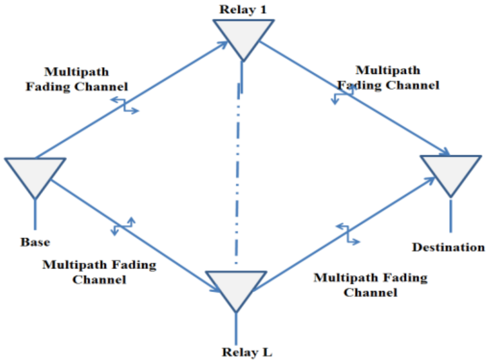

Fig:1- System Model: Distributed space frequency codes

The DSFC with DAF consist of two phases [11]. In phase 1, base node broadcasts the symbol to L relays over M paths. In phase 2, relay forward the decoded information in the matrix form to the destination over M paths. The multipath fading channel between the base node and the l-th relay node is given as,

$$h_{b,r_l}(\tau)=\sum_{m=1}^{M}\alpha_{b,r_l}(m)\delta(\tau-\tau_m)$$

The delay of m-th path is termed as τ_m. α_{b,r_l} Termed as zero mean, complex Gaussian random variables with variance $E\left[|\alpha_{b,r_l}|^2\right]=\sigma^2(m)$. $\delta(.)$ is the Dirac delta function. The channels are normalized such that $\sum_{m=1}^{M}=\sigma^2(m)$ [10].

Here, CRC error correcting code is used at relay, which check all the decoded symbols at every relay and will again re-encode the corrected symbol and forward to the destination node. The number of paths between base node and l-th relay node is same with number of paths between l-th relay node and destination node. That is why it is considered as Symmetric DSFC.

B. Working of S-DSFC system without Direct Link

In phase 1, base node broadcasts the input symbol to L relays. At l-th relay, the received signal in frequency domain over k-th subcarrier is given as[10],

$$y_{b,r_l}(k)=\sqrt{p_b}H_{b,r_l}(k)b(k)+\eta_{b,r_l}(k), \quad (0.1)$$

$$H_{b,r_l}(k)=\sum_{m=1}^{M}\alpha_{b,r_l}(m)e^{-j2\Pi(k-1)\Delta\tau_m} \quad (0.2)$$

where the channel coefficient between base node and the l-th relay node on the k-th subcarrier is modeled as $H_{b,r_l}(k)$. The base node transmitted symbol and the power is given as $b(k)$ and p_b, respectively. $\eta_{b,r_l}(k)$ is additive white Gaussian noise of l-th relay node on the k-th subcarrier that is expressed as zero mean circularly symmetric complex Gaussian random variable with variance $N_o/2$ per dimension. And $f=1/T$ is the subcarrier frequency separation and T is the OFDM symbol duration.

In phase 2, Space frequency code is constructed in matrix form. By applying cyclic redundancy codes (CRC) at relay node, it's easier to detect whether the relay node decoded the information correctly or not. The transmitted K x L space - frequency (SF) code word from the relay nodes is given by

$$C_r=\begin{pmatrix} C_r(1,1) & \dots & C_r(1,L) \\ \vdots & \ddots & \vdots \\ C_r(K,1) & \cdots & C_r(K,L) \end{pmatrix}$$

Where the symbol transmitted to the destination node on the k-th subcarrier by the l-th relay node is represented by C_r. The received signal at destination node is given as,

$$y_d(k)=\sqrt{p_r}\sum_{l=1}^{L}H_{r_l,d}(k)C_r(k,l)I_l+\eta_{r_l,d}(k) \quad (0.3)$$

Where the channel coefficient on the k-th subcarrier between the l-th relay node and the destination node is given as $H_{r_l,d}(k)$. Destination additive white Gaussian noise on the k-th subcarrier and relay node power is given as $\eta_{r_l,d}(k)$ and P_r, respectively. I_l is termed as the state of the l-th relay which is equal to 1 if the l-th relay decodes correctly in phase 1, otherwise it is equal to 0. The base node transmit the information on M paths to L relays, so the S-DSFC without direct link has diversity of order LM, which is maximum achievable diversity [11].

III. PROPOSED SYSTEM

A. DSFC with Direct Link

The proposed system is consist direct link from base node to destination node for both symmetric and asymmetric DSFC with DAF. In proposed system, Fig. 2, the base node broadcast the information to L relays and the destination node over M paths. Similar to Existing system, the proposed system has also two phases. In phase 1, base node broadcast the information to relays and destination node over M paths. The channel between base node and l-th relay node is similar to equation (1.2).The received signal at relay node will be similar to equation (1.1). The received signal at destination node over M paths is given as,

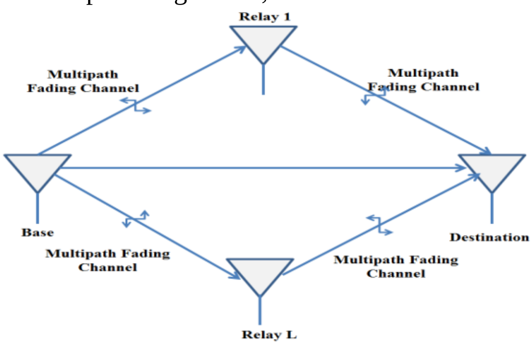

Fig 2- System Model: DSFC with Direct Link

Where the channel coefficients between base node to the destination node on the k-th subcarrier is modeled as

$$y_d(k) = \sqrt{p_b} h_{b,d}(k) b(k) C_r(k,l) I_l + \eta_{b,d}(k)$$

$$h_{b,d}(\tau) = \sum_{m=1}^{M} \alpha_{b,d}(m) \delta(\tau - \tau_m)$$

Where the channel coefficients between base node and the destination node on the k-th subcarrier is modeled as $h_{b,d}(k)$. $\eta_{b,d}(k)$ is additive white Gaussian noise on the k-th subcarrier for destination node. The channel coefficients are known at destination, not at transmitter. The destination node combines the signal which are received from base node in phase 1 and from relay node in phase 2, using maximum ratio combiner [MRC], which multiply input information with its conjugated channel gain [13]. DSFC with direct path is designed to achieve the diversity of order [M+1] L. This diversity is achieved due to two stage coding. First one is base node coding, which gives diversity of order [M+1], as the number of paths between base to l-th relay is M and there is one direct path to destination from base node. Secondly, the relay node coding gives the diversity of order [M+1] L, as the number of relays are L. Thus the proposed DSFC with direct link has diversity of order [M+1] L.

B. Asymmetric DSFC

In symmetric case, the number of paths from base node to relay node are same compared to paths between relay to destination node, which is impractical. Because the the signal over M-th path may get lost or corrupted before reaching to relay. The DSFC with DAF protocol for asymmetric case contain different number paths per fading channel. Let us consider the case where the data transmitted on M path from base node to relay. But at the time of CRC decoding some relay will decide that code properly and some will not. The relay which will decode the data correctly that relay will forward the data to destination node over the channel. The relay which will not decode it correctly will remains idle. So the number of paths from base node to relay node and relay node to destination node becomes different which are denoted by M, N, respectively.

M_{b,r_l} are the number of paths between base node and l-th relay node. And $N_{r_l,d}$ are the number of paths between l-th relay mode and destination node. The maximal diversity for asymmetric case can be achieved by designing the codes at base node and relay nodes using

$$M = \sum_{l=1}^{L} \min\left(M_{b,r_l}, N_{r_l,d}\right)$$

IV. SIMULATION RESULTS

The proposed system is simulated with the help of MATLAB software. For all simulation, four relay and delay is equal to 10 micro second is considered. For this, the two ray model is taken with L=2 paths, where two ray have equal variances. The modulation is OFDM modulation with k subcarriers, where k=128. The system bandwidth is taken as 1MHz. The relaying protocol used at relay node is Decode and forward protocol [DAF], which decodes the information at relay node and then retransmit the information to destination node. The relay is considered at center location from base node and destination node. The power from base node is equal to power from relay. i.e. $P_b = P_r$.

A. DSFC without Direct Link

Fig. 3 shows the simulation of symmetric DSFC and Asymmetric DSFC without direct link. So only base node to relay node and relay node to destination node path is considered. And CRC error correcting code is used at the relay, where the code rate is $R_c = 1/3$. The signal received at destination are combined with the help of MRC combiner, which ensures smaller SER. From *Fig. 3*, it is observed that the asymmetric DSFC without direct link is showing better performance than symmetric DSFC.

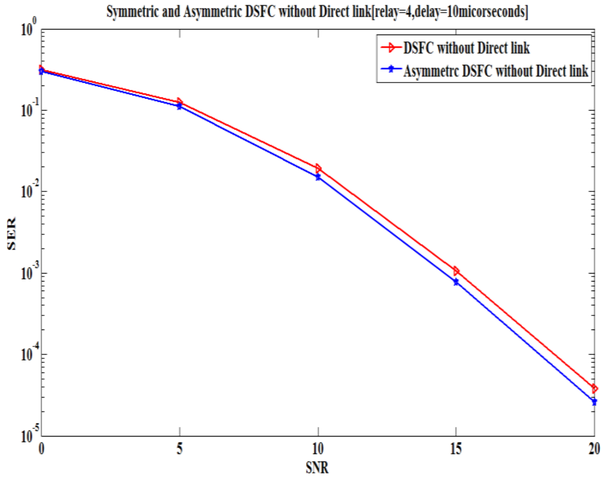

Fig.3- DSFC without direct link, DAF, Four relay, 10 micros delay

B. DSFC with Direct Link

Fig. 4 DSFC with direct link. The cyclic redundancy coding is used in both cases. The DSFC with direct link gives better result than DSFC without direct link because the base node to destination node path is added to recover the information, which increases the performance of the system.

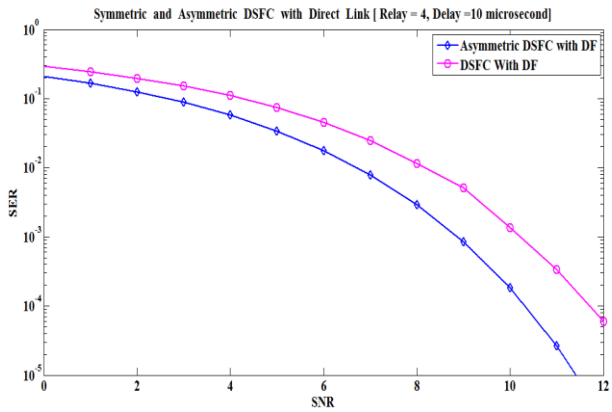

Fig. 4: DSFC with Direct link, DAF. 4 Relays, 10 micros delay

The above simulations are obtained if all relay node to destination link have same quality. If suppose one relay node to destination node link quality is better than second relay node to destination node link quality, then first relay node will give lower SER compared to second relay.

V. CONCLUSION

The Asymmetric DSFC without Direct link is giving flexibility to the system, but in practice the number of paths are different between base node to relay node and relay node to destination node. The addition of direct link from base node to destination node helps to recover the information from base node and can be used to compare it with the received information from relay node. This results into the significant increase in the performance as well as improved diversity order of the cellular network, which is the maximum achievable diversity of the system. The combination of Asymmetric DSFC with direct link gives both flexibility and diversity to the system.

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