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Relay Selection for Multiple Access Relay Channel Using JNCC

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ABSTRACT: Wireless Relaying is a promising solution to overcome the channel impairments and provides high data rate and coverage for beyond 3G mobile communications. By using JNCC (Joint network channel coding) reliable transmission over an error- prone channel can be achieved. It seamlessly couples channel coding and network coding and can effectively combat the detrimental effect of fading its wireless channels. This paper presents a relay selection for JNCC, in which the source node simultaneously transmits their own information to N-number of relays as well as the destination node and best relay will be selected to forward the new version of information. Simulations have been performed to show that BER and FER for multiple access relay as a function of SNR and also SER and outage probability for JNCC. Moreover, the results show that joint network-channel coding with MARC outperforms the single relay.

KEYWORDS: BER,Joint network Channel coding, Multiple access relay channel(MARC), SER

I. INTRODUCTION

Wireless Communication suffers from high and time-varying packet losses due to the detrimental effect of fading of wireless channels. In order to overcome the effects of fading, diversity techniques is an effective tool. When the channel experiences severe fading, the performance of channel coding also degrades dramatically. It is required to add more redundancy to overcome the effect of fading, which can be either inside a packet (redundant bits/symbols at the physical layer) or across multiple packets (redundant packets at the network layer). The first one is called error correction, and the latter is called erasure correction. Channel coding is a conventional error correction technique used for point-to-point communication. On the other hand erasure correction is always used for end-to-end communication. It is implemented at the physical layer and network layer respectively. Both techniques try to increase the reliability and resilience to errors during the transmission, but on different layers. On the physical layer, the redundancy is traditionally used for error-correction, while on the network layer, the redundancy is used for erasure-correction. When treating them separately, the error correction at the physical layer cannot take advantage of the redundancy in the network code and vice-versa.

Joint network coding and channel coding is a more general approach than separate independent network- channel coding [10]. Instead of splitting, the overall problem into two separated tasks, error protection and network information transfer are considered jointly to guarantee error-free decoding at the nodes. A node has to decode the data using the input from all incoming links. If a node has more than one incoming link, error-free decoding at the sink can be possible even if error-free decoding of the point-to-point links is not possible. Joint network-channel coding is useful, if the network code contains redundancy. Analogous to joint source-channel coding where the remaining redundancy after the source encoding helps the channel code to combat noise,[11],[13],[14]. Joint network-channel coding allows exploiting the redundancy in the network code to support the channel code for a better error protection. Joint network-channel coding requires that one channel code is distributed in the network to include several links and is not performed locally for single point-to-point link. Joint network-channel coding approach is more suitable for efficient information transfer in wireless networks with broadcast transmissions.

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In this paper, we propose a relay selection for Generalized-multiple access relay channel that uses JNCC. The main objective of this scheme is to minimize the Bit Error rate by maintaining the same diversity order as that of the conventional cooperative scheme. It is necessary to use joint network channel coding to exploit the additional redundancy which is contained in the transmission of the best relay. This scheme is considered as G-MARC. This scheme uses a simple topology with Number of relays, binary channel coding, and binary XOR Network coding. In this system model, we consider two source nodes, N relay nodes and one destination node. Message that transmits from the two source nodes takes place in two phases. In the 1^{st} phase, both source nodes send the information to all relays simultaneously, the 2^{nd} phase; best relay node is selected to forward the received signals to destination nodes based upon two conditions. The relay that is selected best relay is one which has maximum instantaneous SNR of the channel link between the sources and relays node.

II. Related Work

Recently, a Number of researchers have concentrated to combine these two coding schemes.[1,2,3,5,6].Joint network-channel coding (JNCC) can be interpreted in two ways. A simple approach could be to iterate between the channel code and the 2. Tables, Figures and Equations network code. However, a real joint network channel-code refers in the case where the network code forms an *integral part* of the channel code. The latter has been studied for the multiple access relay channel with Turbo codes [2]. These pioneer papers treat JNCC, but the code design is not immediately scalable to general large networks and most importantly. It does not contain the required structure to have been full-diversity. In[7] a full-diversity joint network-channel coding. (JNCC) For the multiple access relay, channel is proposed, but it doesn't extend to large networks. The work of Hausl et al. was followed by the interesting work [9]

2.1 Main Contributions and Organization of the Paper

The rest of the paper is organized as follows in Section-2 describe a topology with two-sources and multiple access relay channel. The joint network channel coding for multiple access relay channel is described in section 3The strategies of relay selection for MARC in Section 4.The performance analysis provides in Section 5. The simulation results are provided in Section 6. Finally, conclusions are drawn in Section 7.

III. TOPOLOGIES AND PRELIMINARIES

3.1 Topology

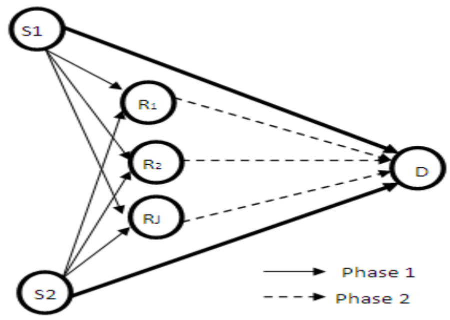

Fig.1 A simple topology with two sources, Multiple access relays and one sink

We first consider a simple two-source, multiple access-relay topologies as shown in Fig.1. In this topology, two sources, *S*1 and *S*2, transmit two independent packets, x1 and x2, to a common sink, D, with the help of N relays, *R*1 ,*R*2….RN. To focus on the joint decoding procedure at the sink node, we assume the channels between the sources and the relays are lossless. Upon receiving x1 and x2, the N relays, will forward redundant packets, through relays (whose contents determine the level of collaborations), to the sink respectively. In the optimal relay selection scheme, as shown by the solid line in Fig 1, each message transmits from the two source nodes takes place in two modes. In the first

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mode, both source nodes send the information to all relays simultaneously. In the second mode, best relay node is selected to forward the received signals to destination node. For the sake of simplicity, we assume that the source and the relay nodes have all the link information. An approximate formula for SER to pick the suitable relay according to the maximum SNR is presented.

IV. JOINT NETWORK-CHANNEL CODING FOR MULTIPLE ACCESS RELAY CHANNEL

In a cellular based mobile communication system Fig. 2 two users S1 and S2 want to transmit statistically independent data, which is segmented into blocks **u**1 and **u**2 of length *K* to the Destination. The information bits **u**1 and **u**2 are protected against transmission errors with channel encoders which output the code bits **x**1 and **x**2 with the block length *N*. The relay R receives the disturbed versions of the code bits **x**1 and **x**2 to obtain the estimates ˆ**u**14 and ˆ**u**24. Regardless whether **u**1 and **u**2 are decoded without errors at the relay, these estimates of the information bits of MS1 and MS2 are jointly combined to the network code bits **x**4 and sent for the base station to provide additional error protection. The network code bits **x**4 have the block length *N*R. The code rate through the system is given by *R*S = 2 · *K*/(2 · *N* + *N*R).

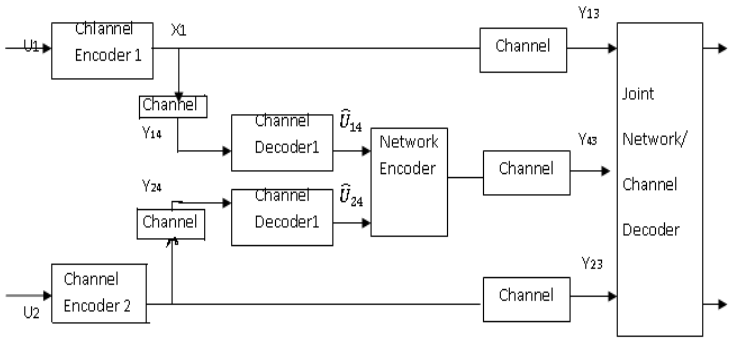

Fig.2 Block Diagram

4.1 Channel Coding

The channel coding strategy is explained in this section. The channel codes at source node1 contain a rate 1/2 recursive systematic convolutional code with constraint length 4 and information bit block length *K* = 1500. The feed forward generator is 15, and the feedback generator is 13, both in octal. As the code is systematic, the output from the channel code contains 1503 systematic bits (including three tail bits) **v***i* and 1503 parity bits **p***i* where *i* {1, 2}. As we want to send *N* = 2000 code bits **x***i*, we puncture the parity bits **p***i* according to the following rule. We only transmit every third parity bit except the parity bits at position 373, 748, 1123 and 1498. This position is chosen such that the puncturing occurs regularly. The joint network-channel code consists of three constituent encoders, which are channel encoder 1 and 2 at the mobile stations form two of three constituent encoders.

4.2 Network Coding

If the relay has decoded the data of both source nodes correctly, the relay network encodes the estimates ˆ**u**14 and ˆ**u**24 and sends the network code bits **x**4 to the base station to provide additional redundancy for both uplinks. A network encoder both estimates are interleaved according to [14]. Then, the interleaved bits appear alternately as the input of a convolutional encoder with the same parameters like the convolution code used as a channel encoder. However, the output from the network encoder contains only the 3003 parity bits of the convolutional encoder. As we only want to send *N*R = 2000 bits, we puncture every third bit and the bits at position 1000 and 2000. The network code of rate *R*R = (2.*K*)/*N*R = 1.5 provides *N*R additional parity bits, which support the decoding at the base station. Although the

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different coding operations are processed spatially distributed, we will treat them as one network-channel code with the system rate $RS = 2 \cdot K/(2 \cdot N + NR) = 0.5$

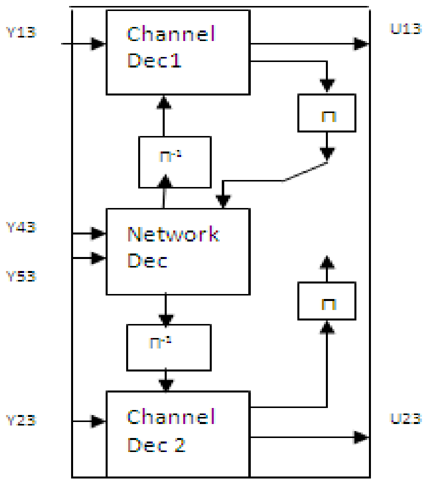

Fig. 3 Joint iterative network and channel decoder at the base station.

As they process the information bits in its original order, they are depicted in horizontal direction. The third constituent encoder is the network encoder at the relay. As it processes the interleaved information bits, it is depicted in vertical direction. The network encoder combines the information bits of MS 1 and MS 2. Therefore, the encoder at the mobile stations and at the relay form one spatially distributed code with increased cooperative diversity.

V. RELAY SELECTION FOR MULTIPLE ACCESS RELAY CHANNEL

The transmission protocol requires two consecutive phases as follows. In the first phase, the encoded transmitted symbol X will be received by relay and destination. Let the topology represents source, s, its destination, d, and relay by r. The received symbols at the destination and relay can be modeled as

$$Y_{SRj} = \sum_{j}^{N} \qquad (1)$$

Where denotes the channel gain between source and j-th relay terminals, denotes source and destination terminals respectively, *x* is the transmitted information symbol. The noise terms are , modeled as zero-mean complex Gaussian random variables with variance In the second phase, relay decides whether to forward the received information or not according to the quality of the received signal. If the relay decodes the received symbol correctly, then it forwards the decoded symbol to the destination. otherwise, it remains idle. The received symbol at the destination from the relay is written as

Where is the channel gain between j-th relay terminal and the destination. The j-th relay gain denoted by G_i is chosen as where E_s is the average energy per symbol.

In single relay selection schemes, only one opportunistic relay transmits the received signal to destination. In previous work, opportunistic relay is defined considering distance toward source or destination [12] or considering the channel condition. In [13] best relay is selected based on a channel condition using analog network coding and DF schemes. The selection of the best relay based on distance is not a good selection since a communication link between transmitter

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and receiver locating in the same distance might have enormous difference in terms of received signal due to fading and shadowing. In [14], authors select the best relay based upon the channel condition.

In this paper, we are focusing best relay selection. In the second-mode of transmission, Best relay is selected out of N-relays to forward the received signals. The selected relay is most opportunistic among all pairs for relaying a signal to destination. This is depending on the SNR of the channel link between the sources and relays node. Rj^{best} may be a more suitable relay will prefer to complete the transmission. The selection of the best relay is not based upon a distance since a communication link between transmitter and receiver locating in the same distance might have enormous difference in terms of receive the signal due to fading and shadowing. Just a single source node (i.e., S) will determine the optimal relay according to a certain criterion and broadcast the index of it to all relays. Then, only the selected one, which is known by both source nodes, is active in the second mode of transmission, and the other keep idle.
Let and denote the total channel power from source to jth relay and jth relay to destination respectively. Here, and describe the quality of the wireless path between source to relay and destination to relay. is calculated by relay j by the following equation.

j=1 (2)

where j=1,2..N

and is the fading amplitude from relay to destination. Since Multiple access relay networks are important for end to end performance, each relay calculates
corresponding based on the two conditions.
Condition 1:

Condition 2:

The relay j that maximizes function is one with the "best" end to end path between initial source to destination. After being selected as the best relay it relays a signal to destination. In this paper, we assume the destination has perfect channel state information available for decoding the received signal.

VI. PERFORMANCE ANALYSIS

In the 1st phase, both source nodes send the information to all relays simultaneously, the 2nd phase; best relay node is selected to forward the received signals to destination nodes based on equations 5 and 6, then it transmits to destination. The selection of the best relay is done by identifying the weaker link between the first hop and the second hop of each relay node. The weak link is ordered and the one which have largest SNR is selected as the candidate relay to perform detection and forward to destination. The end- to- end SNR through this selected relay j is given by

$$\gamma_b = \max_{i \in R}(\gamma_i) = \text{ma} \qquad (3)$$

are the instantaneous SNR of the S-R and R-D link, respectively. We assume the Rayleigh fading channels, for the S-R and R-D link has the same average channel gain the PDF and CDF of SNR in the links are respectively given by
To simplify the analysis an upper bound for the second term of the equivalent SNR is given by.
According to i.i.d links, the CDF expression (9) can be written as.

$$F_{\gamma_b}(\gamma) \qquad (4)$$

The PDF can be obtained by taking derivative of the CDF in (11) with respect to gives

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$$f_{\gamma_b}(\gamma) = N f_{\gamma_v}(\gamma)\left[F_{\gamma_v}(\gamma)\right]^{N-1}$$

$$= N \frac{1}{\bar{\gamma}_v} e^{\frac{-}{\bar{\gamma}_1}} \qquad (5)$$

Then substituting (11) into the definition of MGF,

and computing the integral, we finally obtain the expression to the moment generating function of as follows

We present in this section the selection methods according to JNCC scheme on the system model. Let us first calculate the PDF of SNR in JNCC schemes. Due to symmetric between $\gamma_{s1,j}$ and $\gamma_{s2,j}$ leads to the equality of denoted by PDF and CDF respectively. We use the for derivation of JNCC schemes, which can be written as in (2) and (15) for JNCC scheme as

We derive the average SER expressions for BPSK modulation scheme. Due to the use of MGF of upper bound SNR, the average SER for binary signals is given by

Where g=1 for BPSK. Substituting (14) into (16) and after some manipulations, the average SER in this case can be expressed as.

$$\overline{SER} = \sum_{n=1}^{N} \binom{N}{n} (-1)^{n-1} *$$

$$\frac{1}{\pi}\int_0^{\frac{\pi}{2}} \qquad (6)$$

Where and .Using partial fraction expansions and after some manipulations (17) for the BPSK signaling can be written in closed- form expression as

$$\overline{SER} = \sum_{n=1}^{N} \binom{N}{n} \frac{(-1)^n}{1-2\gamma} \qquad (7)$$

equation (18) represents the average SER from relay selection.

VII. SIMULATION RESULTS

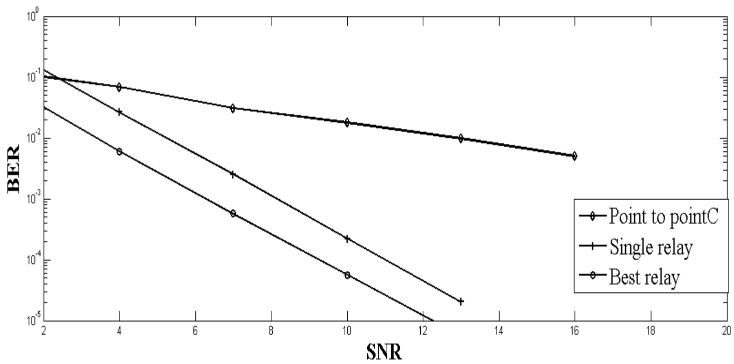

Fig.4 BER Vs SNR for Multiple Access Relay Channel at Nr=1 and Nr=5

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In this section, we provide the simulation results using MATLAB tools for the MARC model. Simulations have been performed to show the BER & FER performance of JNCC over the Rayleigh fading channels for without relay and with single relay in MARC. Fig. 4 and Fig. 5 depict the BER and FER performance.
In the first mode where the two source node simultaneously transmits their own information to all the relays as well as the destination node. As the redundancy which is contained in the transmission of the relay is received with a higher SNR, it is more important to exploit it efficiently. The difference at an FER of 10^{-2} is 2.0 dB.

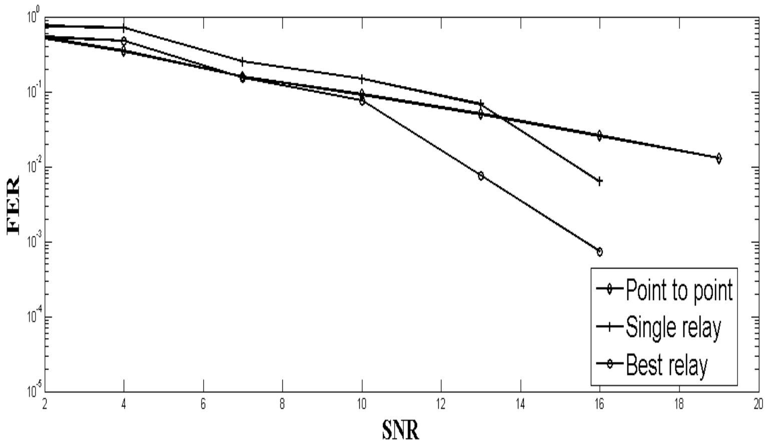

Fig.5 FER Vs SNR For Multiple Access Relay Channel At Nr=5 , Nr=1and Point To-Point

Fig.6 presents the simulation results for SER to pick a best relay among *nR*-relays nodes of JNCC strategies. and Fig.7 depicts the SER and Outage Probability as a function of SNR, where a single relay, i.e. best relay with a minimum symbol error rate (SER) will be selected to forward the new version of the received signal. Fig.6 shows the average of SER of the system model with JNCC for *N*-relays. We can observe that the average SER inversely proportional to a number of relays (i.e. *SER* decrease when the number of relay (increase).

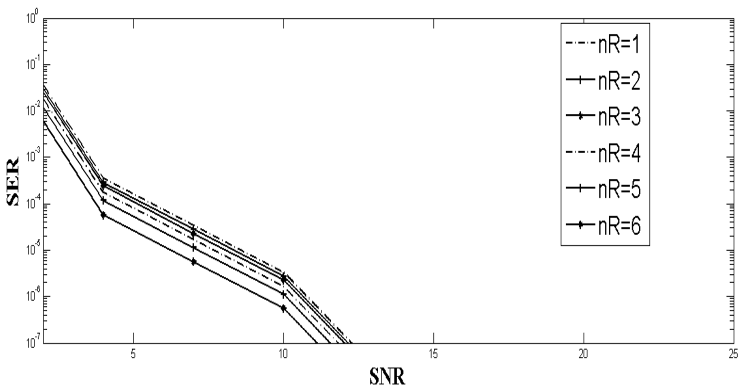

Fig.6 SER Vs SNR for MARC, where nR = 1, 2, 3, 4, 5.

Fig.7 shows that the outage probability versus SNR results for the system model. We can observe from it that the number of relay nodes affect the outage probability (i.e. decrease).

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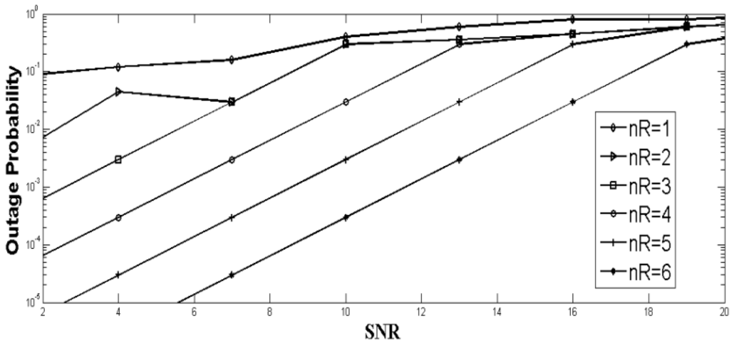

Fig.7 Outage Probability Vs SNR for MARC, where nR = 1, 2, 3, 4, 5.

VIII. CONCLUSION

In this wok, we have proposed a relay selection with JNCC over G-MARC system. Such as the system could be used for the cooperative uplink for two sources to a destination with the help of the best relay .We showed with simulation results that increase in the number of relay channel increases cooperative diversity compared to the single relay channel. Simulation results show that the frame error rate of JNCC can outperform with the number of relays (nR=5). Single relay has of a performance loss of 3.0dB compared to the number of Relay (nR=5) for an FER of 10^{-2}. To improve the system performance, the best relay selection strategy is provided based on the SER.

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