A Reliable Relay Selection index for Cross layer Approach for Cooperative Cellular Networks

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***Abstract*— In any cooperative wireless networks the presence of many mobile stations willing to forward and help in delivering information packets to the destination helps in achieving Cooperative Diversity. The real test is to make sure that the communication is Reliable? Many mobile nodes vary in size and thus having limited energy battery cells and energy scavenging abilities. This paper is on relay selection mechanisms for wireless cellular networks. Our mechanism selects the relays which are satisfying the conditions present at both the physical layer and also at the network layer. For the physical layer we first calculate only those relays in which the Signal to Noise (SNR) ratio to the destination is above the threshold, through which we can further calculate the Bit Error Rates (BER). For the Network layer we use the metric of Network Lifetime and for this we calculate Residual Energy(RE) of the relay nodes. Our algorithm has the advantage of selecting the best relay at both the physical and also at the network layer.**

***Index Terms*— Cooperative Cellular Networks, Rayleigh Fading, Relay Selection, Amplify and Forward, Signal to Noise Ratio, Residual Energy, Bit Error Rate.**

I. Introduction

In Wireless Communications, Cooperative relay technique which allow users within a specific area to form a virtual antenna array to achieve the space diversity effect and improve user's quality of system and system throughput [1]. However, if we consider a wireless communication system as a point of interfering point to point links, then both interferences and fading can be exploited to increase the system throughput and the reliability.As in the distributed wireless systems wherein each node possesses only a single antenna, relays can be used to provide spatial diversity and combat the impact of fading.Recently, there has been increasing interest in combining traditional point-to-point MIMO techniques into multihop wireless relaying networks to support higher end to end (e2e) data rates and to provide a better user experience. The main idea behind Cooperative Communications is that all the other terminals can act as virtual antenna array, performing the so called transmission space diversity. This constitutes a 'two hop' scheme which tries to exploit the different paths between each relay and destination.

Cooperative Communications has attracted great attention of research as it can be employed to achieve spatial diversity without requiring multiple transceiver antennas on the same device. The fundamental idea behind cooperative networks is based on the fact that signals transmitted by a source node to its destination node can also be received by other nodes in a wireless environment. The reason for multi relay cooperative cooperative diversity is to increase the diversity gains and network lifetime to balance the relay resources.Cooperative diversity is a relatively new class of spatial diversity techniques made possible by retransmitting the information of a source through geographically distributed relay nodes in the system.The reason for the multi relay cooperative diversity is to increase diversity gains and network lifetime to balance the relay resources. As channel fading is independent, when each relay link experiences a serious fading, a direct result of increasing the number of relays can decrease power consumption of each relay, thus allowing network to survive longer. Obviously the more relays user selects, the users transmission rate will be higher. But the power consumption and cost will increase. Research shows that the number of relays increased to a certain value, the performance gains become smaller, so there is optimum value of the number of relay nodes. Considering the Residual Energy of node for relay selection would avoid excessive use of good channel, in this way the fairness of network is not compromised. [2], [3], [4], [5] [1]

By sharing the network resources, the nodes in a distributed communication network can harness the benefits of multiple-input multiple-output (MIMO) systems with only a single antenna at each transmitter/receiver. The works in [6], [7], [8], has led to much research activity in the area of cooperative communications. The work in [9], showed that selection, wherein a single best relay helps the source, provides all the benefits of cooperation while minimizing the overhead. Selection cooperation in a single-source single-destination network has been well studied for the DF protocol [10],but is not as well investigated for multiple sources where finding the best relay for each source becomes a combinatorial problem. In such scenarios, one specific relay node can be chosen by multiple sources. Thus, it should share its available power amongst all source nodes which have selected that node as a relay. Due to the fact that most of the mobile stations are battery powered thus we need to develop a distributed and low power relay selection algorithm to maximize the network lifetime. Network lifetime is usually measured by the instance that the first mobile node

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runs out of operating power. [11], [12], [13], [14]

In the case of a single source destination pair choosing the best relay is fairly straightforward and solved for both Decode and Forward(DF), and Amplify and Forward(AF) [15], relaying. In both cases, the best relay is the one that contributes the most to the output signal to nice ratio (SNR). The selection gets significantly more complicated in the more practical case of multiple information flows [16]. Because a relay must now divide its available power between all flows it supports, a relay that is best for a single flow may not remain the best overall and the relay selection becomes a combinatorial problem.

Clearly, selection in diversity is not a new concept. It is arguably the most intuitive way of implementing diversity, and has been thoroughly analyzed in traditional MIMO systems.The novelty of this paper thus lies in the specific application of selection to cooperative diversity systems and analysis in network settings. Nodes in the wireless networks are constrained in their size and often powered by the battery with limit energy supply. Hence, it is crucial to further study the information transmission with minimum power consumption in the multisource and multi-relay cooperative systems.Cooperative communication has attracted great attention of research, as it can be employed to achieve spatial diversity without requiring multiple transceiver antennas on the same device.

The reason for multi-relay cooperative diversity is to increase diversity gains and network lifetime to balance the relay resources. In a wireless network, unbalanced utilization of relays leads to a shortened network lifetime [17]. As channel fading is independent, when each relay-link experiences a serious fading, a direct result of increasing the number of relays can decrease power consumption of each relay, thus allowing network to survive longer.

Nodes in the wireless networks are constrained in their size and often powered by the battery with limit energy supply. Hence, it is crucial to study the information transmission with minimum power consumption in the multisource and multi relay cooperative systems. Obviously the more relays user selects, the users transmission rate will be higher. But the power consumption and cost will increase. Research shows that the number of relays increased to a certain value, the performance gains become smaller, so there is an optimum value of the number of relay nodes [18]. Considering the residual energy of node for relay selection would avoid excessive use of good channel, in this way, the fairness of network is not compromised. This there needs to be a mechanism to devise the algorithm in such a manner that the network lifetime is always available and no node is unreachable in any part of the cellular network region.

II. Best Relay Selection

In [16]. [15], [19], the relay whose path has the minimum SNR is selected. This is obviously the optimal single RS scheme. The error rate of this scheme is first discussed in [16], which uses an approximation on the cumulative density function of the receive SNR. Then a rigorous upper bound on the error rate is given in [16]. Both show that this scheme is achieving the full diversity order of R. [20].

The optimal solution is in the form of selective relaying (SR) where only the relay with the best channel condition is chosen to transmit. Actually, this method is proven to achieve full diversity and it is optimal for several different optimizing criteria, e.g. [21], [22]. Furthermore, it only demands local CSI at each relay, and can be conducted in a distributed manner [23].

III. Reliability at the Physical and Network Layer

The term Reliability should be defined by the application and amount of service that it desires. As in some applications the term is referred to when the data packets are received correctly at the receiver in other applications such as audio and video the synchronization of both image and audio is defined as the reliability of the service. In the communication layer stack the term has been defined at different layers and each layer treats it separately . It is normally used for correcting errors that are too costly to fix at the lower layers of the communication stack. But this has its downside also, as the independent decisions at the respective layers may lead to unreliable and insufficient communication environment. Thus some form of cross layer coordination or optimization needs to be done to achieve better performance levels.

Our algorithm does that by taking into consideration of both the physical layer and network layer metrics. The metrics defined that characterize reliability at the physical layer include the signal to interference plus noise ratio (SINR), bit error rate (BER), symbol error rate (SER), packet error rate (PER), and outage probability. We want to connect the algorithm with the network layer which is routing. It plays an important role also in terms of network and node lifetimes, since it ultimately determines the load of each relay node in the system [24].

IV. System Model for Relay Selection

To maximize the system capacity, only a few relays in good channel conditions should be selected. As if the whole set of relays are used then this will result in shortened network lifetime. [25], [26]. Our algorithm selects the relays based on SNR of each relay to the destination and then drop those relays who are below the outage probability, Those relays who satisfy the outage are selected. The BER of those relays are also calculated. Then finally the amount of RE of the relay node is also calculated and then summed in the Reliabilty index where they are all arranged in an descending order.

In our paper we consider a fading cellular environment in which there is one transmitter ,N number of relays and one destination. The source broadcasts the message to all relays and then the relay sends back its information to the source where the SNR is calculated. CSI information is available to all relays. A half duplex dual hop communication scenario in a fading environment with one MS, one BS and a set of N Amplify and Forward (AF) relays.During the first hop, the source transmits its information to the relays and the destination as is common in Cooperative Communications. While in the second phase, one relay(assume that each time, at most one relay is used)amplifies and forwards the received signal to the destination. The destination combines the signal from both the direct path and relay using the Maximal Ratio Combining (MRC). In cooperative cellular networks, MS and BS act interchangeably as source and destination in the uplink and relaying transmission. To maximize the system capacity, only a few relays in good channel conditions could be selected. This unbalance in relay selection causes poor relay utilization, as well as shortened network lifetime. [25]. Here we consider a half duplex dual hop communication scenario During the first hop, the source transmits its information to the relays and the destination as is common in Cooperative Communications. While in the second phase, one relay(assume that each time, at most one relay is used)amplifies and forwards the received signal to the destination. The destination combines the signal from both the direct path and relay using the Maximal Ratio Combining (MRC). In cooperative cellular networks, MS and BS act interchangeably as source and destination in the uplink and downlink transmission, with relay offering help for both the uplink and downlink communication transmission.

Figure 1 shows a downlink dual-hop cellular communication system. There are M relay nodes. The base station, denoted by s, is communicating with destination node, denoted by d, through a best relay node, denoted by r_j. It is consider that s and r_j use orthogonal channels, either by time, frequency and code, for transmission.Remember that the transmission through the relay nodes either mobile or fixed needs two transmission phases, the spectral efficiency of each phase may be no less than 2R to get an end to end R bits/Hz spectral efficiency. [27] The relay selection algorithm selects relays based on link SNR, denoted by γ and allows (d) to receive two copies of s informations in two time slot.

While Figure 2 show our methodology of finding the best relay among any number of relay nodes, transmission from other relays is not done as they do not have suitable conditions to the destination. Thus the destination combines the signal from the direct path and also the best relay.

The objective of the network life time is to increase in performance thus the nodes should consume energy in a balanced fashion, so the residual node energies should also be taken into account. We define a new cost metric taking into account all these factors, and use this metric to choose the cooperation set and to determine the end-to-end path. [28]

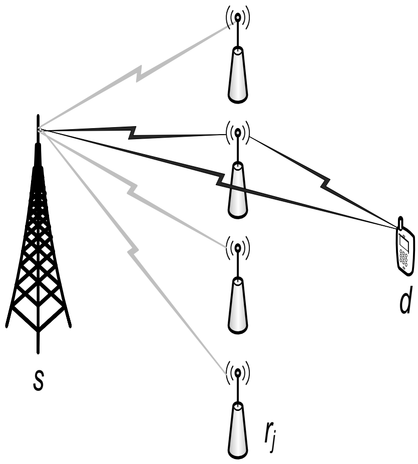

Figure 1. A Cooperative Cellular System with Relay Stations

V. Cross Layer Approach to Find Reliability Index

The formula for the total calculation. and also the metrics calculated and also the reliability that are considered at the Physical and Network layer and how they affect the performance:

$$\text{RI}(X) = \text{Max}\left[\text{RI}_{\text{NetworkLayer}}(X) + \text{RI}_{\text{PhysicalLayer}}(X)\right]$$

Where we define the $\text{RI}_{\text{NetworkLayer}}(X)$ as the selection of the SNR and BER of the relay nodes and thus we give them weights

$$\text{RI}_{\text{PhysicalLayer}}(X) = 0.3(\text{SNR}) + 0.2(\text{BER}) \quad (1)$$

$$\text{RI}_{\text{NetworkLayer}}(X) = 0.5(\text{CE}) \quad (2)$$

We now proceed with our calculation in selecting the relays SNR and also calculate the outage probability.

VI. SNR of the Relay node

Figure 1 shows a downlink dual-hop cellular communication system. There are M relay nodes. The base station, denoted by s, is communicating with destination node, denoted by d, through a best relay node, denoted by r_j. It is consider that s and r_j use orthogonal channels, either by time, frequency and code, for transmission.Remember that the transmission through the relay nodes either mobile or fixed needs two transmission phases, the spectral effeciency of each phase may be no less than 2R to get an end to end R bits/Hz spectral efficiency. [27] The relay selection algorithm selects relays based on link SNR, denoted by γ and allows (d) to receive two copies of s informations in two time slot.

It is assumed that fading in the channel is independent and identical Rayleigh distributed, all channel gains are perfectly known to transmitters and receivers and there are N subcarriers. The instantaneous signal-to-noise ratio (SNR), i.e., γ^i_{xy}, of the j-th relay link using i-th subcarrier is

$$\gamma^i_{xy} = P^i_x {h^i_{xy}}^2 / \sigma^2, \quad (3)$$

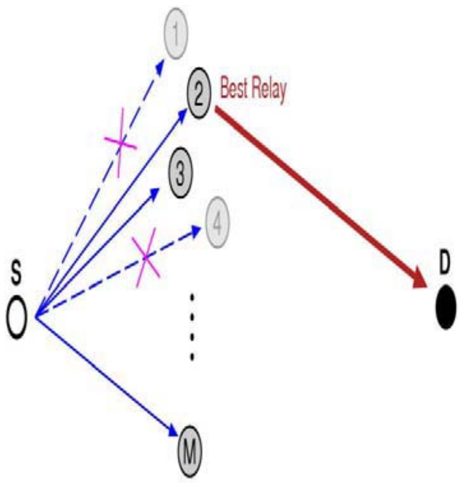

Figure 2. A Cooperative Cellular System with Relay Stations

where $x \in \{s, r_j\}, y \in \{r_j, d\}$, h_{xy}^i is the channel coefficient between x and y, σ^2 is the variance of additive white Gaussian noise (AWGN) and P_x^i is the transmit energy/symbol of x node. The average SNR, i.e., $\bar{\gamma}_{xy}^i$, can be written as

$$\bar{\gamma}_{xy}^i = \mathbf{E}[\gamma_{xy}^i], \tag{4}$$

where $\mathbf{E}(.)$ is the expectation operator.

Since maximal-ratio combining (MRC) is used at the destination, the instantaneous SNR at the d using r_j link, denoted by γ_{sr_jd}, can be written as

$$\gamma_{sr_jd} = \min(\gamma_{sr_j}, \gamma_{r_jd}). \tag{5}$$

The total SNR of a primary link, denoted by γ, can be written as

$$\begin{aligned} \gamma &= \gamma_{sd} + \gamma_{sr_jd} \\ &= \gamma_n^{sd} + \min(\gamma_n^{sr_j}, \gamma_n^{r_jd}) \\ &= \left[\frac{P^s {h_{sd}}^2}{\sigma^2} + \frac{P^s {h_n^{sr_j}}^2 P^{r_j} {h_{r_jd}}^2}{\sigma^2(\sigma^2 + P^s {h_{sr_j}}^2 + P^{r_j} {h_{r_jd}}^2)} \right] \end{aligned} \tag{6}$$

In any terrestrial wireless system, the transmitted signal is reflected, scattered and diffracted by many objects such as building, trees, hills, ground etc. Thus the received signal is the complex signal of point to point, reflected, scattered and diffracted component of the transmitted signal. The relative path lengths are also changing time to time. This results due to the movement of source destination and the any moving object between them. The received signal continuously changes the phases and amplitude. The multipath channel statistics follow the Rayleigh fading model.

The instantaneous SNR per symbol of the Rayleigh channel fading, denoted by $f(\gamma_{XY})$ between $X - Y$ link is distributed according to the exponential distribution given by []

$$f(\gamma_{XY}) = \frac{1}{\bar{\gamma}_{XY}} \exp\left(-\frac{\gamma_{XY}}{\bar{\gamma}_{XY}} \right), \tag{7}$$

where γ_{XY} and $\bar{\gamma}_{xy}$ are the instantaneous and average SNR of the $X - Y$ link at n-th subcarrier respectively.

The CDF of the γ_{sr_jd} ,i.e., $F(\gamma_{sr_jd})$, is derived in [30] as

$$F(\gamma_{sr_jd}) = 1 - 2\gamma_{sr_jd} \sqrt{\frac{1}{\bar{\gamma}_{sr_j}\bar{\gamma}_{r_jd}}} e^{-2\gamma_{sr_jd}\left(\frac{1}{\bar{\gamma}_{sr_j}} - \frac{1}{\bar{\gamma}_{r_jd}} \right)} K_1\left(2\gamma_{sr_jd} \sqrt{\frac{1}{\bar{\gamma}_{sr_j}\bar{\gamma}_{r_jd}}} \right), \tag{8}$$

The joint PDF of γ_{sr_j} and γ_{r_jd}, denoted by γ_{sr_jd}, is the harmonic mean of these two exponential random variables [31]. It can be deduced as

$$f(\gamma_{sr_jd}) \frac{2\gamma_{sr_jd} e^{-2\gamma_{sr_jd}\left(\frac{1}{\bar{\gamma}_{sr_j}} - \frac{1}{\bar{\gamma}_{sr_j}} \right)}}{\bar{\gamma}_{sr_j}\bar{\gamma}_{r_jd}} \left[\left(\frac{\bar{\gamma}_{sr_j} + \bar{\gamma}_{r_jd}}{\sqrt{\bar{\gamma}_{sr_j}\bar{\gamma}_{r_jd}}} \right) K_1\left(\frac{2\gamma_{sr_jd}}{\sqrt{\bar{\gamma}_{sr_j}\bar{\gamma}_{r_jd}}} \right) + 2K_0\left(\frac{2\gamma_{sr_jd}}{\sqrt{\bar{\gamma}_{sr_j}\bar{\gamma}_{r_jd}}} \right) \right]. \tag{9}$$

Let, $\frac{2}{\sqrt{\bar{\gamma}_{sr_j}\bar{\gamma}_{r_jd}}} = \alpha$ and $\bar{\gamma}_{sr_j} + \bar{\gamma}_{r_jd} = \nu$. Since γ_{sd} and $\gamma_n^{sr_jd}$ are independent, the PDF of $\beta = \gamma_{sd} + \gamma_n^{sr_jd}$ can be written as

$$f(\beta) int_0^{\beta} f_{sr_jd}(\gamma) f_{sd}(\beta - \gamma) d\beta \tag{10}$$

$$= \int_0^{\beta} \gamma \frac{\alpha^2}{2} e^{-\gamma\frac{4\nu}{\alpha^2}} \left[\frac{2\nu}{\alpha} K_1(\nu\gamma) + 2K_0(\nu\gamma) \right] \frac{1}{\bar{\gamma}} e^{-\frac{\beta-\gamma}{\bar{\gamma}}} d\gamma. \tag{11}$$

Equation (12) can be written as

$$f(\beta) = \int_0^{\beta} f_{sr_jd}(\gamma) f_{sd}(\beta - \gamma) d\beta \tag{12}$$

$$= \int_0^{\beta} \gamma \frac{\alpha^2}{2} e^{-\gamma\frac{4\nu}{\alpha^2}} \left[\frac{2\nu}{\alpha} K_1(\nu\gamma) + 2K_0(\nu\gamma) \right] \frac{1}{\bar{\gamma}} e^{-\frac{\beta-\gamma}{\bar{\gamma}}} d\gamma. \tag{13}$$

Equation (12) can be written as This is the CDF equation of Rayleigh fading channel considering $SR - RD$ link, and it is important to note that in cooperative networks as we have SD and SRD link it is important to have the joint PDF and joint PDF is the convolution of $f_s rd, f_s d$ Equation (**??**) can be written as

$$\begin{aligned} f(\beta) &= \frac{\alpha^2}{2\bar{\gamma}} e^{\frac{\beta}{\bar{\gamma}}} \int_0^{\beta} \gamma e^{-\gamma\frac{4\nu}{\alpha^2}} \frac{2\nu}{\alpha} K_1(\nu\gamma) e^{\frac{\gamma}{\bar{\gamma}}} d\gamma \\ &+ \frac{\alpha^2}{2\bar{\gamma}} e^{\frac{\beta}{\bar{\gamma}}} \int_0^{\beta} \gamma e^{-\gamma\frac{4\nu}{\alpha^2}} 2K_0(\nu\gamma) e^{\frac{\gamma}{\bar{\gamma}}} d\gamma. \end{aligned} \tag{14}$$

But,

$$\int_0^\beta \gamma e^{-\gamma\frac{4\nu}{\alpha^2}}\frac{2\nu}{\alpha}K_1(\nu\gamma)e^{\frac{\gamma}{\bar\gamma}}d\gamma = \frac{\nu}{\alpha^3}\bar\gamma e^{-\frac{4\nu^2}{\alpha^3}}K_1(\nu\gamma)C + D \quad (15)$$

where

$$C = \left(\alpha^2\Big(- e^{\frac{4\bar\gamma\nu^2}{\alpha^4}} + e^{\frac{(-2\bar\gamma\nu+\alpha^2\beta)^2}{\alpha^4\bar\gamma}}\Big)\right) \quad (16)$$

(17)

$$D = 2\nu\sqrt{\bar\gamma\pi}\Big(Erfi\left(\frac{2\sqrt{\bar\gamma}\nu}{\alpha^2}\right) - Erfi\left(\frac{2\bar\gamma\nu-\alpha^2\beta}{\alpha^2\sqrt{\bar\gamma}}\right)\Big) \quad (18)$$

$$\int_0^\beta \gamma e^{-\gamma\frac{4\nu}{\alpha^2}}2K_0(\nu\gamma)e^{\frac{\gamma}{\bar\gamma}}d\gamma = \frac{1}{\alpha^2}\bar\gamma e^{-\frac{4\nu^2}{\alpha^3}}K_0(\nu\gamma)C + D \quad (19)$$

Putting the value of Equations (15) and (19) in the Equation (14), and simplifying, we have

$$f(\beta) = \frac{\alpha^2}{2\bar\gamma}e^{\frac{\beta}{\bar\gamma}}\left[\frac{1}{\alpha^2}\bar\gamma e^{-\frac{4\nu^2}{\alpha^3}}C\left(\frac{\nu}{\alpha}K_1(\nu\gamma)+K_0(\nu\gamma)\right)+2D\right] \quad (20)$$

Equation (**??**) can be written as

$$f(\beta) = \frac{1}{2}e^{\frac{\beta}{\bar\gamma}-\frac{4\nu^2}{\alpha^3}}C\left(\frac{\nu}{\alpha}K_1(\nu\gamma)+K_0(\nu\gamma)\right)+\frac{\alpha^2}{\bar\gamma}e^{\frac{\beta}{\bar\gamma}}D \quad (21)$$

VII. Outage probability Calculation

The outage probability of combined $S-R_j-D$ and $S-D$ links is investigated in this section. An outage event occurs, when the link SNR falls below a specific threshold. Consider, the threshold SNR is $\Gamma = 2^{2R_{min}-1}$, where R_{min} is the minimum data rate. The outage probability, i.e., P^{OUT,r_j}, can be written as

$$P^{OUT,r_j} = \int_0^\Gamma f(\beta)d\beta \quad (22)$$

$$= \int_0^\Gamma \frac{1}{2}e^{\frac{\beta}{\bar\gamma}-\frac{4\nu^2}{\alpha^3}}C\left(\frac{\nu}{\alpha}K_1(\nu\gamma)+K_0(\nu\gamma)\right)d\beta + \int_0^\Gamma\frac{\alpha^2}{\bar\gamma}e^{\frac{\beta}{\bar\gamma}}Dd\beta \quad (23)$$

After further simplification, Equation 23 can be written as

$$P^{OUT,r_j} = \frac{1}{2}e^{-4\nu/\alpha^2}\bar\gamma C(e^{\Gamma/\bar\gamma}-1)\left(\frac{\nu}{\alpha}K_1(\nu\gamma)+K_0(\nu\gamma)\right) - \alpha^2 D(1+e^{\Gamma/\bar\gamma}) \quad (24)$$

VIII. Bit Error Rate (BER) Analysis

While the SNR calculations may satisfy some requirements still we want to decide upon the BER of the selected relay. For this we do the BER analysis of Combined $S-R_j-D$ and also the S-D links. For a specific channel the SNR is equal to

$$P_b(\gamma_n) = \frac{1}{2}\text{erfc}(\sqrt{\gamma}) \quad (25)$$

The BER for the binary phase shift keying (BPSK) in Rayleigh fading channel, denoted by $P_b(\beta)$, can be obtained in the following.

$$P_b(\beta) = \frac{1}{2}\int_0^\infty \text{erfc}\left(\sqrt{\beta}\right)f(\beta)d\beta \quad (26)$$

Now putting the value of Equation 18 we get the following

$$P_b(\beta) = \frac{1}{2}\int_0^\infty \text{erfc}\left(\sqrt{\beta}\right)[\frac{1}{2}e^{\frac{\beta}{\bar\gamma}-\frac{4\nu^2}{\alpha^3}}C\left(\frac{\nu}{\alpha}K_1(\nu\gamma)+K_0(\nu\gamma)\right)] + \frac{\alpha^2}{\bar\gamma}e^{\frac{\beta}{\bar\gamma}}Dd\beta \quad (27)$$

Now using the [32], the first and second part of the equations can be solved in the following manner:

$$P_b(\beta) = \frac{1}{4}\exp^{\frac{-4\nu^2}{\alpha^3}}C\frac{\nu}{\alpha}K_1(\nu\bar\gamma)\int_0^\infty \text{erfc}\sqrt{\beta}\exp^{\frac{\beta}{\bar\gamma}}d\beta) + \frac{1}{4}\exp^{\frac{-4\nu^2}{\alpha^3}}C\ K_0(\nu\bar\gamma)\int_0^\infty \text{erfc}\sqrt{\beta}\exp^{\frac{\beta}{\bar\gamma}}d\beta + \frac{1}{2}\frac{\alpha^2}{\bar\gamma}D\int_0^\infty \text{erfc}\sqrt{\beta}\exp^{\frac{\beta}{\bar\gamma}}d\beta \quad (28)$$

After simplifying the equations we get the following

$$\frac{1}{4}\exp^{\frac{-4\nu^2}{\alpha^3}}C\frac{\nu}{\alpha}K_1(\nu\bar\gamma)\int_0^\infty \text{erfc}\sqrt{\beta}\exp^{\frac{\beta}{\bar\gamma}}d\beta \quad (29)$$

$$= \left|\frac{\bar\gamma^{\frac{3}{2}}}{\sqrt{1+\bar\gamma}}\text{erfc}\left[\sqrt{\frac{\beta(1+\bar\gamma)}{\bar\gamma}}\right] - \exp^{\frac{-\beta}{\bar\gamma}}\bar\gamma\text{erfc}\left(\sqrt{\bar\gamma}\right)\right|_0^\infty \quad (30)$$

After applying the limits we get the following

$$A = \bar\gamma - \frac{\sqrt{1+\frac{1}{\bar\gamma}}}{1+\bar\gamma} \quad (31)$$

Similar will be the result for the others. Thus the final equation will be as follows.

$$P_b(\beta) = \frac{1}{4}\exp^{\frac{-4\nu^2}{\alpha^3}}C\frac{\nu}{\alpha}K_1(\nu\bar\gamma)A + \frac{1}{4}\exp^{\frac{-4\nu^2}{\alpha^3}}C\ K_0(\nu\bar\gamma)A + \frac{1}{2}\frac{\alpha^2}{\bar\gamma}DA \quad (32)$$

IX. Residual Energy of a relay node

Those relay nodes whose Residual energy factor is low against the threshold are not held up for promoting the communication further process even though by doing so, we are lossing the total capacity of the network thus to make the network last more and be more active more longer the use of cooperative communication algorithm must use each node in a very balanced and fair approached so that each and signal relay has equal opportunity in forwarding information.

Aksu and Ercetin, 2007, have developed a new cost metric which takes into account the RE of the relay nodes and then from the cooperating relays set chooses the end to end path for participating relays. Here it is important to point that our algorithm only considers the amount of energy that will be needed to transmit the packets towards the destination and is not concerned with the energy required for receiving the packets being forwarded.we select the most reliable node which is considered to have the minimum transmission power needed to broadcast the information to the destination.

One of the main points which are not really considered in the relay selection is that the downlink traffic load may be larger than that in the uplink when the MS downloads some files from the BS. In this scenario, since the relay transmits signal to the MS more often than to the BS, the MS relay channel maybe have more influence than the BS-Relay channel over relay selection. In most of the literature and scenarios discussed before the Cooperative cellular networks, MS and BS act interchangeably as the source and destination in the downlink transmission with the relay offering help for both. [33]

In the scope of energy-efficiency estimation methodologies, a measure usually taken for the comparison of radio transmission technologies is the energy consumption per information bit [34], [35]. However, in cooperative cellular networks, a comparison of the sheer energy consumption is not suitable, because certainly the MS, relay and BS have different power consumption challenges. [36] proposed a relay selection algorithm based on the fuzzy theory. It considered the node residual energy for the best single relay selection.

However, most of the existing works focus on minimizing the transmission power to meet the QoS constraint at the destination without considering the residual battery energy of each relaying node. Thus without the balanced energy consumption among nodes, some parts of the network may run out of battery and rapidly become nonfunctional while other parts may still have a large amount of remaining energy. [23]

Thus, we use the weighted total energy consumption of MS, relay and BS in the two way communication, and allocate different weights to MS,relay and BS, denoted by m_w, r_w,b_w, respectively. These weights are defined based on criteria of priority level on power consumption of MS, relay and BS. They can be set arbitrary values according to different condition. In this paper, we only account for the energy consumed by MS and the relay, and ignore the energy consumption of the BS. This is reasonable as the MS and relay are all powered by batteries while the BS is always powered by a fixed line. [37].

As the channel quality may be poor but the RE of a node is high, it may be stand in front, so the dynamic multi-relay selection algorithm is sub-optimal, but it has relatively low computational complexity. It ensures the poor robustness relay would not participate in the cooperation. Even though that his may lead to loss of total capacity. [38]

In order for the algorithm to work properly, the nodes need to periodically collect the residual energy information from the nodes in the network. This information can be collected at each augmentation step. Note that it is clear from [13] that the residual energy information is needed from those nodes that can be part of the cooperation set and from the candidate next-hop nodes. The extend of the residual energy information collected from the network is a design parameter: Larger the available information, more route choices would be available. However, the larger the information, more energy would be consumed in collecting it. In order to limit the amount of information collected in the network, we assume that only the nodes that are in SNR greater than threshold or outage to a source can be in the cooperation set.

In order to limit the amount of information collected in the network, we assume that only the nodes that are in r distance to a source can be in the cooperation set. Also, we assume that the cluster size is at most N_{max2} . This requirement combined with a maximum transmission power limit ensures that only a certain number of nodes in the network can be reached by the source node. Therefore, nodes do not need the complete network topology Information

Now we need to select those relays for the radio transmission that initially satisfy the requirement of SNR and drop the other relays with low SNR against threshold. This is reasonable as if we are calculating all relay nodes Residual Energy (RE) of all relay nodes then it will create delay in real time traffic. Thus the weighted total energy consumption of the cooperative communication per information bit can be expressed as We model only the energy required for radio transmission and not the energy consumed for receiving. This is reasonable as the radio transmission is the dominant component of energy consumption for long range transmissions [34]. Thus,the weighted total energy consumption of the cooperative communication per information bit can be expressed as [33]

$$CE = \frac{1}{2R}\left[\mu\left(m_w P_m^u + r_w p_r^u\right) + (1-\mu)\left(r_w P_r^d + b_w p_b^d\right)\right] \tag{33}$$

Here it must be clear that only those nodes are selected who have previously been having a higher SNR ratio as compared to the outage probability. Here we define two terms $\left|h_i\right|^2$ and $\left|g_i\right|^2$ which define the channel gain between the MS and the relay and BS and the relay respectively. The symbol δ represents the ratio of the total traffic in the upload to the total traffic.

BS selects the best relay from list under the following criteria, and broadcasts the index of the best relay along with the transmitting power allocated to MS and the relay in UL and DL transmissions. In order to minimize the total energy consumption, we optimize the transmitting power of all transmitters in both UL and DL to the minimum required for successful transmission at an end-to-end data rate R, which are:

$$p_m^u = \frac{T_1}{|h_i|^2}; p_r^u = \frac{T_2}{|g_i|^2}; p_r^d = \frac{T_3}{|g_i|^2}; p_b^d = \frac{T_1}{|g_i|^2}; \quad (34)$$

$$Z = N_o\left(2^{2r} - 1\right) \quad (35)$$

Where T_1;T_2 and T_3, represent the threshold values that take place between the different channels from the MS to Relay, Relay to BS and also in the uplink and downlink communication process. The values for each are given as:

$$T_1 = Z; T_2 = Z\left(1 - \frac{|H_{\text{direct}}|^2}{|h_i|^2}\right); T_3 = Z\left(1 - \frac{|H_{\text{direct}}|^2}{|g_i|^2}\right) \quad (36)$$

$$\text{CE} = \frac{Z}{2r}.\frac{(\mu.m_w + (1-\mu).r_w)}{|h_i|^2} + \frac{\mu.r_w + (1-\mu).b_w}{|g_i|^2} - \frac{r_w|h_{\text{direct}}|^2}{|g_i h_i|^2} \quad (37)$$

The communication process can also take place the direct path;

$$\text{CE}_{\text{direct}} = \frac{\mu.m_w.P_m^u + (1-\mu)b_w p_b^d}{R} \quad (38)$$

$$\text{CE}_{\text{direct}} = \frac{Z.\mu.m_w + (1-\mu)b_w}{R} \quad (39)$$

Here th_1, th_2, th_3 denoted the threshold between the different channels from the MS to Relay, Relay to BS and also in the uplink and downlink. They are equal to

$$\text{th}_1 = N_0 B\left(2^{2R} - 1\right); \text{th}_2 = N_0 B\left(2^{2r} - 1\right)\left(1 - \frac{|h_{\text{direct}}|^2}{|h_i|^2}\right);$$

$$\text{th}_3 = N_0 B\left(2^{2R} - 1\right)\left(1 - \frac{|h_{\text{direct}}|^2}{|g_i|^2}\right) \quad (40)$$

In this paper, we select the relay which minimizes the weighted total energy consumption of communication as best relay,BS compares the E_{direct} with E_{Coop}, and choose the one with the minimum weighted energy consumption. If $E_{\text{direct}} \leq E_{\text{Coop}}$, no relay is selected as the direct transmission is more energy-efficient than the transmission via any relay. As less power will be used to provide communication successfully.

X. Simulations and Results

The outage probability of the best selected relay (for $\bar{\gamma}^{sd} = \bar{\gamma}^{sr_i} = \bar{\gamma}^{r_i d}$) is shown in Figure . Solid curve shows the analytical results of Equation 20. Which shows that for 20 relay's outage will increase and for less relay outage will decrease. The simulation is run for 5000 times It is assumed that channel fading is Rayleigh, modulation is BPSK, combining method at the destination is MRC. The delay is such that the OFDM symbol is flat for a particular transmission.To validate the proposed relay selection technique, we simulate a cooperative network consists of one source one destination and 20 relay nodes generates randomly in the cell. It is the analysis of BER when the error occurs as we have calculated a tolerance level and after that the system is considered to be in outage. The simulation parameters used for calculating the Residual energy are the same as those proposed in [33].

If we look at diagram we can see that for 10 relay outage will increase and for less relay outage will be decreased it is directly proportional.In the second diagram we can see that, if the relay increases BER and data rate both decrease as can be seen that if no cooperative communication $R_s d - ber$ is high and if we are using cooperative communication then $R = min(R_s d, R_s rd$; so thus if cooperative link is bad then data rate R will also decrease. The last figure shows how the different reliability index values select the outage probability and also performance. So if the best relay is selected then the network lifetime and also reliability factors are satisfied as relay selection was done from cross layer methodology. in the figure 4.5 shows the througput analysis of the different users . our algorithm can maintain almost same data rate as of the algorithm in zhang et al. 2009 and it outperforms teh fixed allocation. the sligth difference in performance is due to the allocation of the best carriers to the worst users in our case while algorithm of theirs allocates best carriers to the best users. it is also observed from this figure that with low value of SNR, the throughput of the fixed allocation A perfroms better than fixed allcation B whereas fixed allocation B performs better than fixed allocation A for high SNR. it is due to the allocation of more subcarriers in te low snr region and allocation of more power in the high snr region.

the figure 5 shows the outage probability analysis of the RI selection algorithm and selection AF with power allocation algorithm Zhao et al.2006, for $Rmin = 1$. The RI performs better better at low and medium SNR while a close matched is observed with SNR is higher than 18db. figure 5 11 shows the BER analysis of the RI based relay selection algorithm, blind search and informed search li and erkip 2005 algorithms. the direct path performance is also evaluated . we observe tht informed search is better than no cooperation or blind search algorithm. the proposed algorithm outperforms blind and informed search algorithms. the RI based relay search algorithm alwwas selects the best relay. the effect of queuing delay on teh BER peformance is shows that its peformance

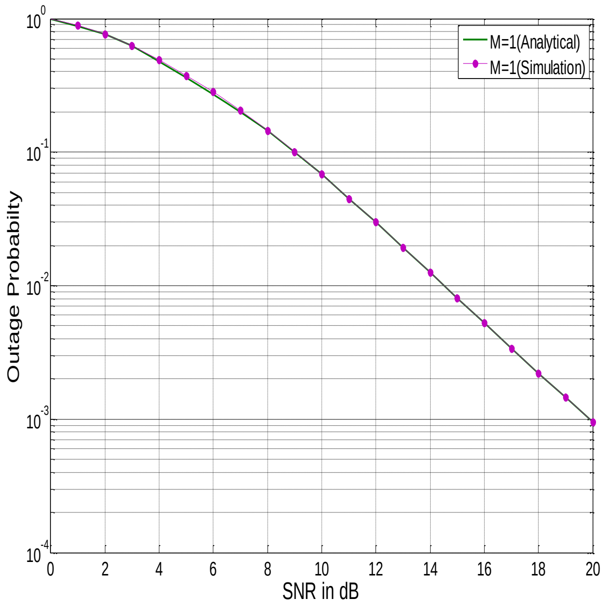

Figure 3. Analytical vs Simulation Model of SNR

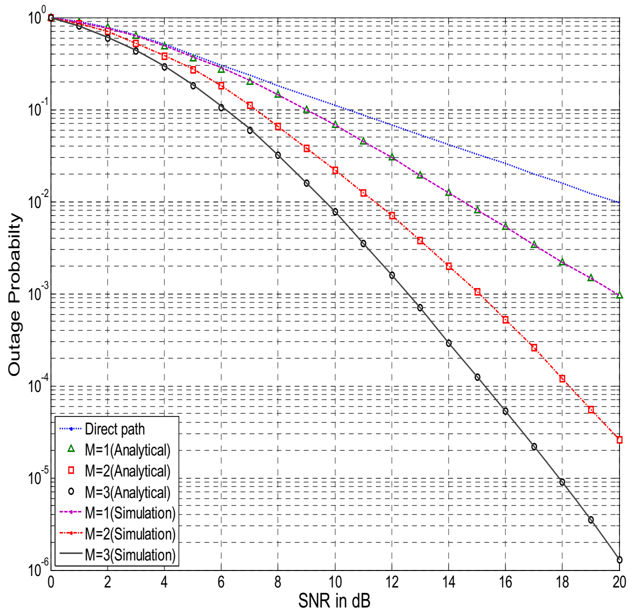

Figure 4. A Cooperative Cellular System with different Relay Stations

degrades as queuing delay increases.

XI. Conclusion

In order to optimize the performance of cooperative communication system, this paper presents a Relay selection methodology based on various factors considering the SNR,BER and Residual Energy of the relay node into consideration before selection is done. This improves the lifetime of the total network. That relay is selected which has a higher index of the factors mentioned. Thus we are using only one relay and not whole relays in forwarding data. Our algorithm keeps in mind that many mobile nodes maybe having limited energy so that should not be used in forwarding information but for keeping itself active in the network.

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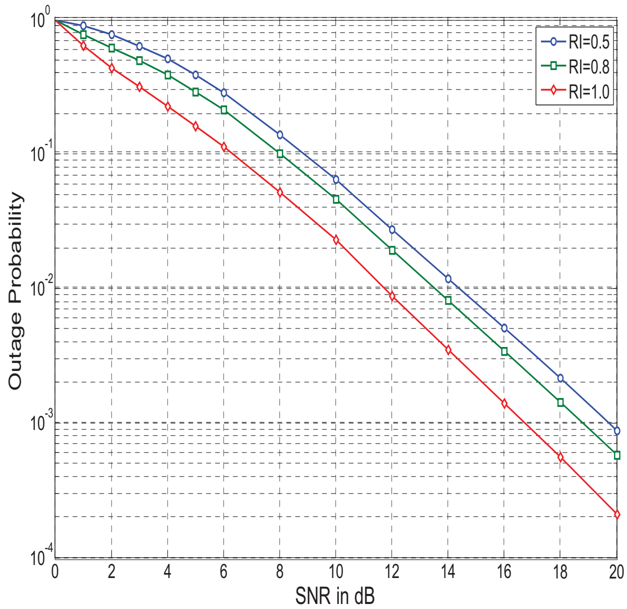

Figure 5. RI Against Different SNR Values

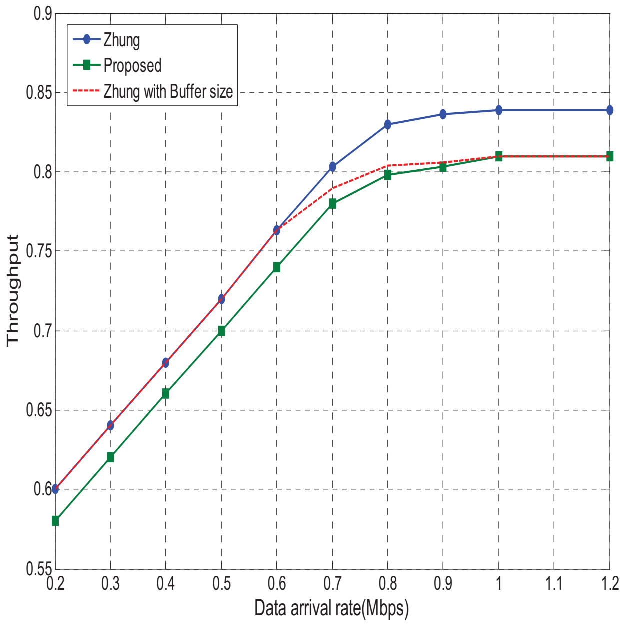

Figure 6. Our Algorithm vs [15]

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