SAGE Based Channel Estimation In An Af Relaying Network

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Abstract **– The basic goal of any communication system is to develop a better and reliable information transfer between a source and a destination, using minimum power and bandwidth .In a communication system the network will be affected by the fading. To overcome the fading, various diversity techniques are available now spatial diversity is one among them; in which diversity is created by using other terminals to relay the information from the source to the destination terminal. In order to achieve the channel between the different antenna pairs to be uncorrelated, the spacing between the antennas must be in the order of wavelength. So, multiple antennas will give rise to an increased hardware cost. For overcoming this limitation a cooperative communication model can be introduced. The basic aim of the project is to estimate the unknown channel parameters from the broadcasted signals which can be done using Space Alternating Generalized Expectation-Maximization (SAGE) algorithm, to iteratively estimate the channel parameter from the pilot part of the information. The affine transformation on the received signal is done by the relays. The error is minimized using Maximum Likelihood (ML) criteria. In order to obtain the lower bound of the error Modified Cramer Rao Bound (MCRB) is used. Finally the Mean Square Error (MSE) and the Frame Error Rates (FER) are estimated after matlab simulation**.

Index Terms **– Keywords: amplify and forward, channel estimation, cooperative communication, SAGE algorithm, Cramer-Rao lower bound**

I. Introduction

The basic aim of this project is to solve the major problem of channel estimation in an amplify and forward relaying networks. Wireless communication enables wireless communication that is impossible to implement with the use of wires. In telecommunication, a system is a collection of individual communication networks, transmission systems, relay stations, usually capable of interconnection and inter cooperation to form an integrated whole. But in the communication system, interference is a serious problem which degrades the system performance.

The main goal of communication system is to establish a reliable information transfer between a source and a destination, using a minimum of power and bandwidth resources. In wireless networks affected by multi path propagation, this reliability is determined by the probability that the channel between the source and the destination is in a deep fade. The proposed has the virtue of low complexity, high speed and strong real time character to environment. A relay network is a broad class of network topology which is commonly used in wireless networks, where some nodes are used for interconnection between the source and destination. Since the distance between the source and destination is greater than the transmission range of both of them they cannot communicate between each other, hence there is a need for intermediate nodes to relay data. Spatial, temporal or frequency diversity techniques enables multiple parallel independent channel to convey the same information between the source and destination in which case the reliability of the system is now determined by the probability that all channels are simultaneously experiencing deep fade. Here concentration is given on spatial diversity.

To ensure channel between the antenna pairs not to be un correlated, spacing between the antennas should be within the order of their wavelength, so, if multiple associate antennas are used it create to an increased hardware value, and is additionally not possible once the dimensions of the terminals are tiny. So as to beat this issue a cooperative communication model is used. During this technique the allotted slots are divided into frames, and also the initial slots are used for broadcasting information and also the remaining slots is utilized by alternative terminals to relay their information to the destination. Hence, higher responsibility is achieved since multiple version of a similar info is received via completely different channels.

The cooperative relaying network consists of 3 nodes, particularly the source, the destination, and a third node, the relay supporting the direct communication between source and destination denoted as relay. If the transmission mechanism of a message from supplies to destination isn't absolutely in, the overheard info from the supply is forwarded by the relay to achieve the destination via a unique path. Since the 2 communications took a unique path and happen one once another, this instance implements the conception of house diversity and time diversity. The relaying ways is additional distinguished by the Amplify-and-Forward (AF), Decode-and-Forward (DF), and Compress-and-Forward (CF) strategies: The AF strategy permits the relay to amplify the received signal from the supply node and to forward it to the destination. Relays following the DF strategy take in transmissions from the supply, decrypt them and just in case of correct decipherment, forward them to the destination. The CF strategy permits the relay station to compress the received signal from the supply node and forward it to the destination while not decipherment the signal wherever wyner-ziv writing is used for best compression. Here AF strategy is employed.

To achieve a low complexity relay, channel gain and noise variance ought to be estimated, if the channel gain data is not available, these estimates will be obtained from the pilot symbols sent together with the information symbols. However the disadvantage of this technique is that the excess use of power and bandwidth, here large number of pilot symbols are required for this estimation, so in order to overcome this difficulty, in this paper a few pilot symbols are used for initial estimates, and so improves the estimates iteratively by using an space Alternating Generalized Expectation maximization (SAGE) algorithm. The Cramer-Rao bound (CRB) and Modified Cramer-Rao Lower bound (MCRB) are used for estimating the mean sq. errors.

II SYSTEM DESCRIPTION

Consider a wireless relay system that consists of source, relay and destination nodes. It is assumed that the channel is in a half-duplex, orthogonal and AF relaying mode. Differently to the conventional direct transmission system, we exploit a time division relaying function where this system can deliver information with two temporal phases.

On the first phase, the source node broadcasts information xs toward both the destination and the relay nodes. The received signal at the destination and the relay nodes are respectively written as:

$$r_{d,s} = h_{d,s} x_s + n_{d,s} \quad (1)$$

$$r_{r,s} = h_{r,s} x_s + n_{r,s} \quad (2)$$

Where $h_{d,s}$ the channel from the source to the destination nodes, $h_{r,s}$ is the channel from the source to the relay node, $n_{r,s}$is the noise signal added to $h_{r,s}$ and $n_{d,s}$ is the noise signal added to $h_{d,s}$.

On the second phase, the relay can transmit its received signal to the destination node except the direct transmission mode.

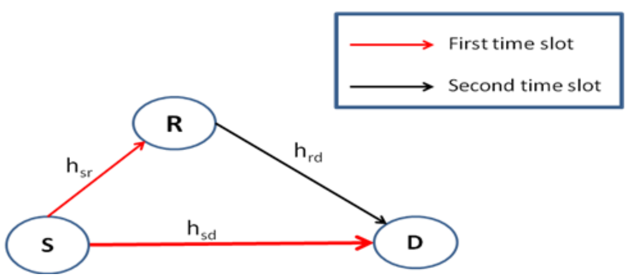

Fig .1Network containing a source S, a relay R and a destination D

A system with one relay is depicted in Fig.1.The extension to multiple relay is similar to this. During the first slot, the source S broadcasts a vector c = (c_p, c_d) of K symbols, consisting of K_p pilot symbols (denoted c_p) and K_d data symbols (denoted c_d), with $K = K_p + K_d$. The pilot symbols are included to assist the estimation of the channel parameters. The data symbols c_d result from first encoding (at rate k/n) a vector of information bits b, and subsequently mapping the encoder output onto a constellation $\mathbb{S}$. The energy per pilot symbol and the energy per data symbol take the same value Es, yielding $|c_p|^2 = K_p E_s$ and $E[|c_d|^2] = K_d E_s$. The average transmitted energy per symbol Es and the symbol rate R_s are related to the energy per information bit E_b and the information bit rate R_b by

$$E_s = \frac{K_d}{K_p + K_d} \frac{k}{n} \log_2(|\mathbb{S}|) E_b, \quad (3)$$

$$R_s = \frac{K_p + K_d}{K_d} \frac{n}{k} \frac{R_b}{\log_2(|\mathbb{S}|)} \quad (4)$$

For given E_b and R_b, the inclusion of pilot symbols reduces E_s (loss of power efficiency for detection) and increases R_s (loss of spectral efficiency).The channels are affected by fading, which is constant over a slot, and are characterized by the channel coefficients h_i and the noise vector w_i (i ϵ {SD, SR, RD}) The elements of the noise vectors w_i are independent zero-mean circular symmetric complex Gaussian (ZMCSCG) random variables with variances $N_{0,i}$. The subscripts SR, SD and RD refer to the source-relay (S-R), source-destination (S-D) and relay destination (R-D) channels, respectively. Denoting the normalized power of the line of sight path by ρ^2_i , the carrier-to-multipath ratio (C/M) or K factor of the Rice fading is given by $\rho^2_i/(1 - \rho^2_i)$ with $\rho_i \in [0;1]$. The channel coefficients are $h_i = \sqrt{H_i}(\rho_i e^{j\varphi i} + n_i)$, where n_i is ZMCSCG distributed with variance $1 - \rho^2_i$, φ_i is uniformly distributed in $(-\pi, \pi)$ and $E[|hi|^2] = H_i$. Note that $\rho_i = 0$ corresponds to Rayleigh fading where the coefficients h_i are ZMCSCG distributed with variance H_i, whereas $\rho_i = 1$ corresponds to an additive white Gaussian noise (AWGN) channel with channel coefficients equal to$\sqrt{H_i} e^{j\varphi i}$.

The signal received by the destination D during the first slot is given by $r_{SD}=(r_{SD,p} ,r_{SD,d})$,with

$$r_{SD,q} = h_{SD},C_q + w_{SD,q} \qquad \text{where } q \in \{p,d\} \quad (5)$$

And $w_{SD} = (w_{SD,p} , r_{SD,d})$ denote the additive white Gaussian noise . Similarly the signal r_{SR} received during the first time slot at the relay R is $r_{SR} = (r_{SR,p}, r_{SR,d})$, where $r_{SR,p}$ and $r_{SR,d}$ are obtained by replacing in equation (5) the subscript SD by SR. As we consider the Amplify-and-Forward protocol, the relay amplifies the data-dependent signal $r_{SR,d}$ with gain γ and transmits the result during the second slot. Hence the corresponding signal received by the destination is given by

$$r_{D,d} = \gamma h_{RD}\, r_{SR,d} + w_{RD,d}$$
$$= \gamma h_{SRD} c_d + w_{SRD,d} \quad (6)$$

with $h_{SRD} = h_{RD}\, h_{SR}$, when conditioned on h_{RD}, the elements of $w_{SRD,d}$ are ZMCSCG distributed with variance given by

$$N_{SRD} = \gamma^2 |h_{RD}|^2 N_{0,SR} + N_{0,RD} \quad (7)$$

For the pilot symbol part, the relay transmits an affine transformation $a + r_{SR,p}B$ of the received pilot signal $r_{SR,p}$, where a and B have dimensions Kp and Kp × Kp, respectively. Here a and B represent a relay pilot symbol vector and a linear transformation of the vector $r_{SR,p}$, respectively. This yields

$$r_{RD,p} = h_{RD}(a + r_{SR,p}B + w_{RD,p} \quad (8)$$
$$= h_{RD}a + h_{SRD}c_pB + n_p,$$

and when conditioned on h_{RD}, n_p is ZMCSCG distributed with covariance matrix Np given by

$$N_p = |h_{RD}|^2 N_{0,SR} B^H B + N_{0,RD}\, I_{Kp}$$
$$= (N_{SRD} - N_{0,RD}) / \gamma^2\, B^H B + N_{0,RD}\, I_{Kp} \quad (9)$$

The gain γ to be applied to the data part $r_{SR,d}$ is chosen such that the average energy per frame transmitted by the relay is equal to KE_r: this yields,

$$KE_r = KdE_{r,d} + K_pE_{r,p} \quad (10)$$

Where $K_dE_{r,d}$ and $K_pE_{r,p}$, denote the average energy transmitted by the relay during the K_d data symbol intervals and the K_p pilot symbol intervals, respectively.

A Flow Chart Description

Fig.2 shows the flow diagram of the system.Initially the known channel parameter are defined such as signal to noise ratio, capacity of the channel, bit error rate, signals are transmitted from the source to the relay via in the non recursive rate encoded form. The broadcasted signal comprises of 'K' symbols, with K_p pilot symbols and K_d data symbols. The data to be transmitted by mapping the encoder output onto a constellation 'S'.PSK(Phase Shift Keying) is the method used for it. Pilot symbols are introduced so as to support the estimation. Data is received by the relay and it is then retransmitted to the destination. For this the protocol used is an amplify and forward (AF) relaying protocols. Then the estimation of the overall channel gain is performed at the destination. Since the data is transmitted using non- recursive rate convolution coding the best and efficient method for decoding is viterbi algorithm (VA).

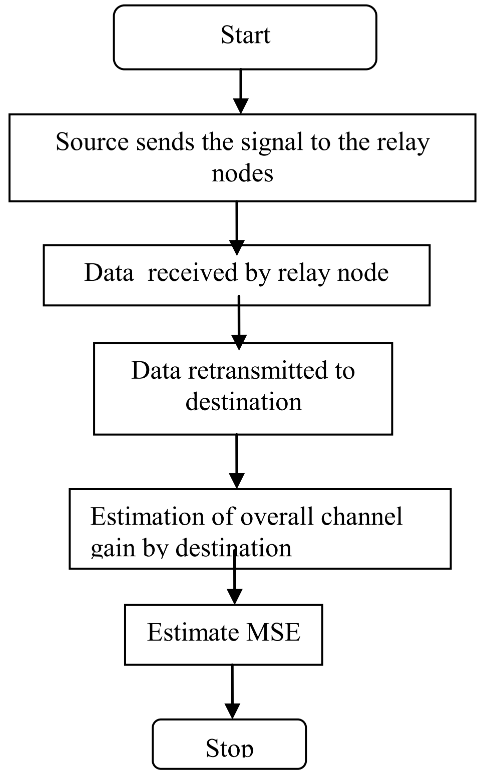

Fig.2 Flow diagram

III RESULTS AND DISCUSSIONS

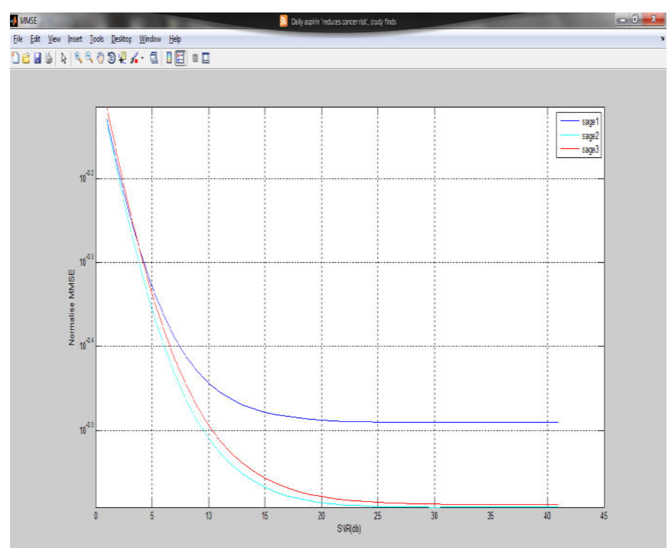

Fig.3 Graphical representation of normalized MSSE versus SNR values

Fig.3 shows the graphical representation of normalized MSSE for different values of SNR for different SAGE iterations. x- axis consists of signal to noise ratio and the y-axis consists of normalised minimum mean square error. The blue colour corresponds to the first iteration denoted as SAGE

1, similarly red and green colour corresponds to the next two iterations, SAGE 2 and SAGE 3.

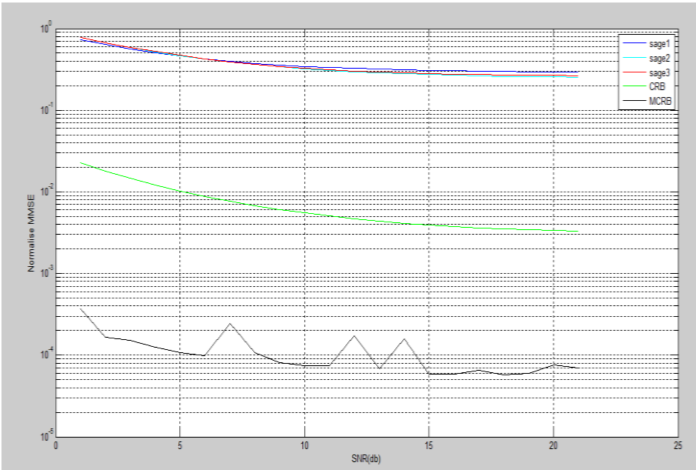

Fig:4 Normalised MMSE Versus SNR Using Cramers Rao Bound

Fig.4 shows the normalized MMSE for different values of SNR using Cramers Rao Bound,to determine the lower bound.

IV CONCLUSION

The Amplify-and-Forward protocol and use the Space-Alternating Generalized Expectation-maximization (SAGE) algorithm to estimate the channel gain and noise variance in an iterative way. A new bound on the mean square error has been investigated. The estimation algorithm exploits not only the pilot part of the received signal, but also the random data part. In a first scenario the relay performed a more sophisticated operation on the source pilot symbols than on the data symbols, and optimized the relay parameters to minimize the MSEE of the pilot-based channel gain and noise variance estimates. In a second scenario, we considered the sub-optimal solution whereby the relay simply amplifies the pilot symbols received from the source. The resulting MCRBs were derived. By means of simulations it showns that at moderate to high SNR the MSEE performance for both scenarios is very close to the obtained MCRBs.

In the future work the Frame Error Rate (FER) can be obtained in which it could be expected to achieve an improvement of 1db SNR as compared to the pilot based estimation.

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