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Performance Analysis of Relay Protocols WithAdaptive Modulation and Coding In LTE-A System

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Abstract

In this paper,a novel method is proposedfor throughput optimization scheme for relay protocols based on Adaptive Modulation and Coding. The performance of relay protocols with the AMC scheme is better than in fixed modulation. The relay protocols with the AMC scheme are capable of providing better Signal to Noise ratio level as compared to the conventional scheme with no AMC. We perform 3GPP LTE-A based parameters to prove the performance comparison of adaptive modulation and coding schemes with non-adaptive relay protocols. The relay protocols which discussed here are Amplify and Forward, Decode and Forward and Demodulate and Forward. The goal is to maximise the data throughput and efficiency.

Index terms: Adaptive Modulation, Decode and Forward, Amplify andForward, Demodulate and Forward

Introduction

Adaptive Modulation and coding is a term used in wireless communication to denote the matching of modulation, coding and other signal and protocol parameters to the conditions on the radio link. The process of Link adaptation is a dynamic one and its signal and protocol parameters change in accordance with the conditions of the radio channel.AMC improves rate of transmission and bit error rates, by exploiting the CSI that is present at the transmitter.The simplest cooperative relaying network consists of three nodes, namely source, destination and a third node supporting the direct communication between source and destination denoted as relay.The three types of relay protocols as stated in [1] are:

1 Amplify and Forward

2 Decode and Forward
3 Demodulate and Forward

The amplify and forward strategy allows the relay station to amplify the received signal from the source node and to forward it to the destination station.The decode and forward strategy overhear transmissions from the source, decode them and in case of correct decoding, forward them to the destination. Whenever unrecoverable errors reside in the overheard transmission,the relay cannot contribute to the cooperative transmission.The Demodulate and Forward technique is an alternative to the Decode and forward scheme to reduce receiver power consumption due to channel decoding at the overall delay at the destination. In the DF schemes described in [9], the relay forwards the source's message only if it is able to successfully decode. However, in many applications, channel decoding may not be desirable at the relays either due to limited transceiver capabilities or due to the lack of knowledge of the channel codebook. So in this case, the signal transmitted by source can only be detected or demodulated on a symbol-by-symbol basis.Generally in a cellular technology, all users within a coverage cell have to be provided with the service. But the mobile users at the edges of the coverage area receive less signal power. The users must be provided with optimum level of signal power. Hence relay acts as repeaters which are used for backhauling and thus transmits high power signal to the receiver user. Hence it acts as intermediate node. To improve the performance of relay protocols, we use Adaptive modulation and Coding to get required throughput.. Relay based network architecture shows promising interest in potential and practical applications as LTE-Advanced. Cooperative communications can exploit the distributed spatial diversity in multiuser systems to combat the impairments of wireless channels. This is particularly useful when each node can only be equipped with a single antenna. As stated in [11] , without channel feedback, the cooperative protocols AF, DF etc can offer a diversity gain by allowing nodes a fair opportunity to transmit messages through their own channel. On the other hand if CSI is available to the users, the system can re-allocate the radio resource among the senders to improve the communication efficiency. According to [12], all the nodes are allowed to adapt their data rates to match the channel conditions, such that the throughput is maximized. Motivated by this fact, we consider adaptive modulation for various protocol systems. AMC can provide high spectral efficiency, meanwhile the reliability of data can be guaranteed.

Proposed Model

In figure 1, we describe the structure of the adaptive-MCS system with RN operation as described in [6]. At the evolved node B(eNB),the data is coded ,interleaved, modulated and then, transmitted through the channel. Once at the receiver the channel condition is estimated with an SNR criterion, and this information is sent back to the transmitter which decides which modulation and coding scheme (MCS) level to use. The previous channel condition parameters are stored in a buffer. When the signal arrives at the Relay Node (RN),weselect the protocols for various scenarios by first considering the channel parameters given by the Channel Evaluator(CE) from the RN-UE link. As per the performance of CE, the suitable MCS level is chosen for the best throughput performance. Choosing the MCS level means to select a specific code rate and modulation scheme according to the estimation of the channel conditions.According to [2],based on the idea of pre-evaluated channel quality, we select the favourable relay protocol. This data is then sent to User Equipment (UE). The UE also analyses the CE, based on the channel condition between RN-UE links. If the channel condition is favourable,a higher order of modulation and code rate are used. Otherwise, a low order of modulation and code rate are selected. With the appropriate MCS level, AMC can obtain both excellent throughput performance and quality for a specific channel condition.

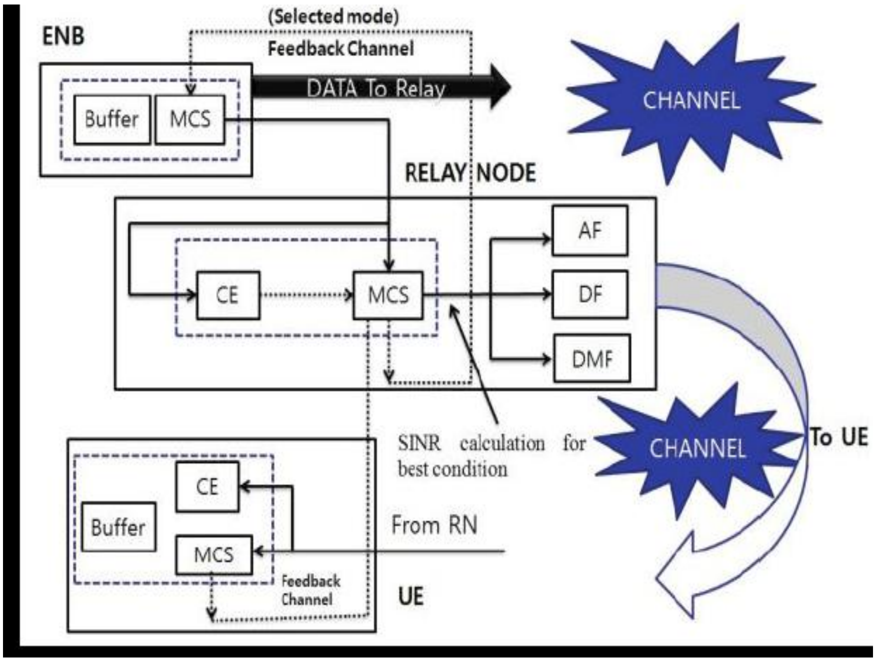

Figure 1: Block Diagram of Adaptive MCS system

Assume that the channel gains are completely known at the transmitter and the receiver and remain unchanged during a packet transmission, In a block fading channel, it is feasible to implement a reverse link to send back channel information and the assumption is practical. At the relay node we process three types of protocol types AF,DF and DMFprotocols. The AF and DF protocols are considered as conventional protocols in the fixed relay system which are already adapted by LTE-A. We analyse the consistency and efficiency of the DMF protocol with MCS comparing the results of conventional designed algorithms, stated in [13].

Design of Relay

Adaptive Modulation and Coding is performed for several SINR regions in the channel. Here, the first consideration is the region boundary for the modulation regarding the modulation adaptation among various schemes of modulation as QPSK and 16-QAM,with a code rate of 1/3 and 3/4.Let Y_s and Y_r denote the received SINR of the SR and RD link. P_{sr} and P_{rd}denote the error probability for the Source-Relay link and Relay-Destination link, respectively. If the RN can obtain data correctly with the probability of (1-P_{sr}),the final errors are calculated from the detection of the combined SD and RD link, P_{sd}. When the relay cannot acquire the data correctly at the SR link the probability is given by P_{sd}. According to [8] ,the total BER for this state is given by,

$$P_e=(1-P_{sr})P_{sd}+P_{sr} \tag{1}$$

We know that BER of M-QAM modulation can be
Obtained as,

$$\boldsymbol{P} = \boldsymbol{\alpha} Q\sqrt{\boldsymbol{\beta} \boldsymbol{\Upsilon}} \tag{2}$$

Where Q is given by

$$Q(x) = \frac{1}{\sqrt{2\pi}}\int_x^{\infty} e^{-u^2/2} du$$

Where α and β are decided by the modulation scheme. But, the above scheme is complex for inversion. So, to simplify the above design and performance analysis, we model the expression, where n is the MCS level, as

$$BER_n(\Upsilon_n) \doteq a_n exp(-b_n \Upsilon) \tag{3}$$

Methodology

The relay protocols considered in our researchpaper are AF, DF and DMF. We will now evaluate various relay protocols with AMC. Fig.2 shows aflowchart of the Relay scheme with AMC. Firstly, the Channel State Information (CSI) is calculated based on the link condition and estimation. Then each protocol is selected as per the situation since all protocols have the same amount of maximum throughput. For example at first, we select the DMF protocol. Afterwards, we check the given MCS level. In the MCS level, we then check the value of the code rate and modulation. When satisfied as defined by the condition, we again check the CSI for the next link of relay and the UE, as stored in the buffer at the relay node. Based on the estimation of theCSI, we make the error check of the present CSI and previous CSI. If the state is true we can then calculate the final throughput estimate as per the given MCS level; otherwise we need to recheck the MCS level and append the new CSI value in the relay node. Then, we need to verify the MCS level for the RN-UE link. Once the throughput is estimated, the new data frame, which is needed to be transmitted to the UE with lower error probability, needs to be verified. The dotted part in the flowchart shows the main performance area in the algorithm.

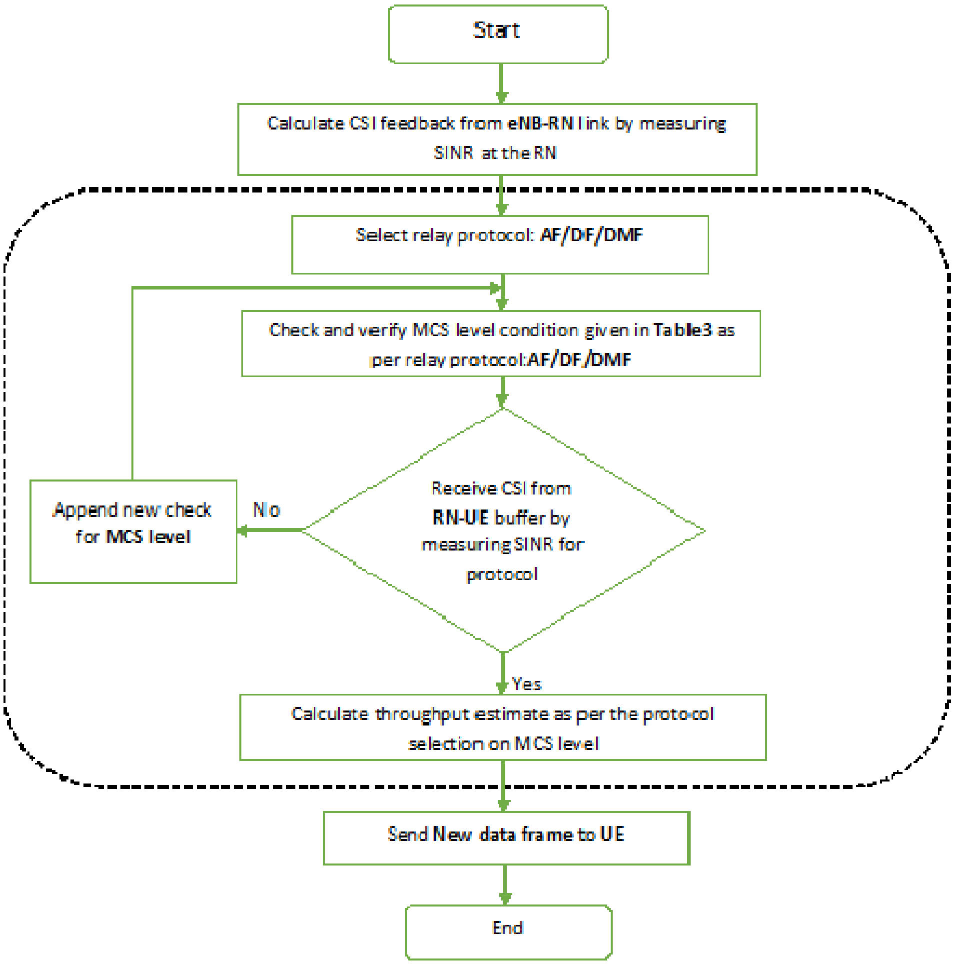

Figure 2: Flowchart

Simulation Results

First fixed modulation is performed and then adaptive modulation is performed and for various relay protocols , the BER performance is evaluated.

Table 1: Fixed Modulation Parameters

IFFT size	512,2048
No. of subcarriers	512,2048
No. of subbands	1,4
Carrier Frequency	2GHz
Symbol Duration	71.3 microsecs(66.6+4.7)
Frame size	10ms
Pilot type	Block
Modulation Type	QPSK,16 QAM,64 QAM

Bandwidth	8MHz,35MHz
No. of pilots	8
No of data/OFDM symbol	504

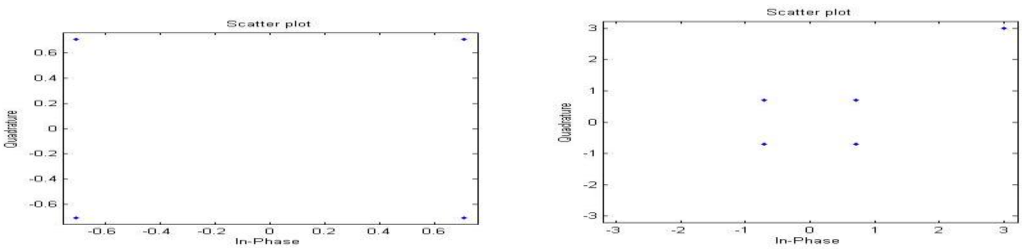

Figure 3a: Constellation Diagram for QPSK before and after the insertion of pilot symbols

Table2: No of bits for modulation

Modulation Type	**No. of bits/OFDM symbol**
QPSK	1008
16-QAM	2016
64-QAM	3024

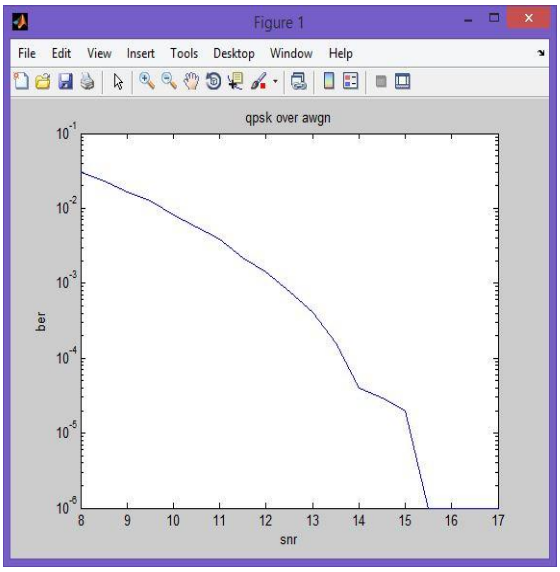

Figure3b: BER Curve for QPSK

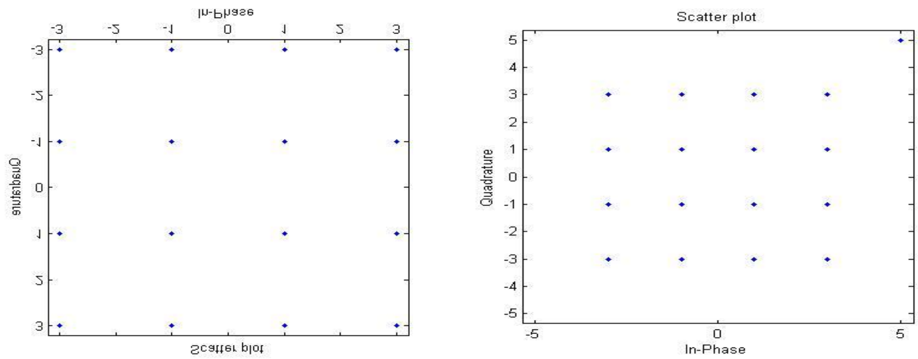

Figure 4a: Constellation Diagram for 16-QAM before and after the insertion of pilot symbol

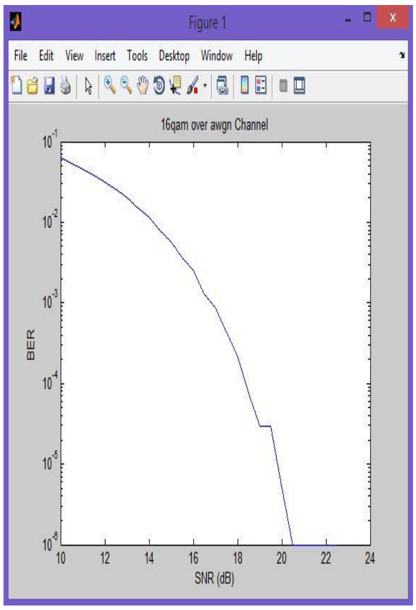

Figure 4b: BER curve for 16-QAM

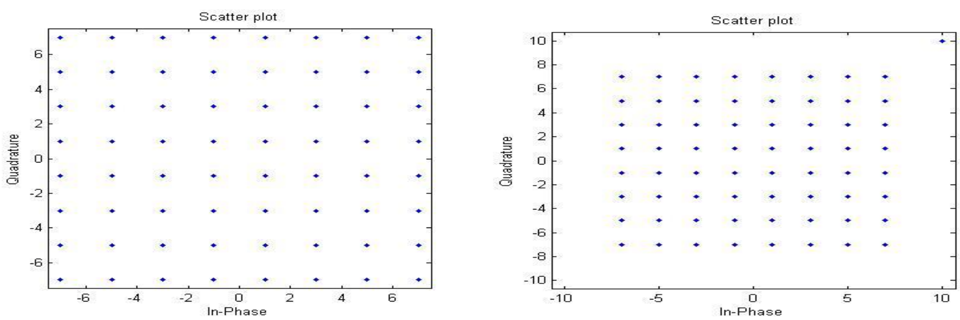

Figure 5a: Constellation diagram for 64-QAM

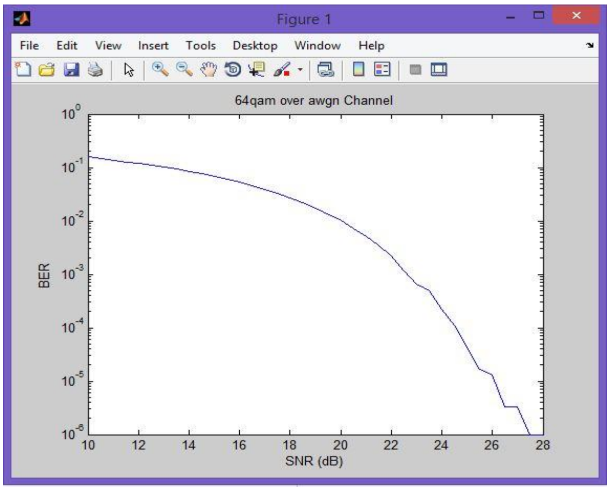

Figure 5b:BER curve for 64-QAM

Theoretical Values of BER when channel SNR is 20db are calculated for QPSK=10^{-6},16-QAM=10^{-4},64-QAM=10^{-2}.

Table 3: Simulation Parameters for Adaptive Modulation

SINR<16	NO DATA
16<=SINR<21	QPSK
21<=SINR<26	16-QAM
SINR>26	64-QAM
No. ofbits	12096
IFFT size	2048
No. of Subbands	4
No. of Pilots	4*8=32

The BER is found to be of 10^{-4}bymatlab simulation. Theoretically, best case value of BER is 10^{-4}, moderate value is 10^{-2} and worst case value is 10^{-1}.

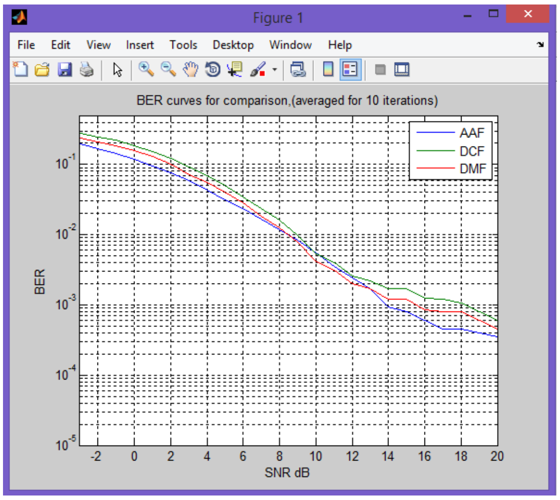

Figure 6: BER curve with Relays

From figure 6, it is seen that when SNR=10dB, the DMF protocol gives low value of Bit error rate in both cases.AF and DF show close performance at low SNR value. The theoretical values and practical values of BER at SNR=10dB are summarized in the table 3.

Table3:BER comparison of Relay Protocols

RELAY PROTOCOLS	THEORETICAL BER	PRACTICAL BER
AF	10^{-4}	10^{-2}
DF	10^{-2}	10^{-2}
DMF	10^{-3}	10^{-2}

Conclusion

The simulation results of the proposed system with Adaptive MCS prove that among the AF,DF and DMF protocols, the DMF protocol performs best especially at low SNR values and also provides better average throughput. We observed that the proposed DMF protocol is capable of performing with the best performance in lower and high SNR values and with high consistency and provides the best throughput efficiently. The main consideration point in the proposed mechanism is the application of the DMF protocol, which when implemented with the AMC scheme shows outstanding results compared to the conventional AF and DF schemes.

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