The Performance of Cooperative MIMO Scheme under Slow Fading Channel based on Fountain Code

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The Performance of Cooperative MIMO Scheme under Slow Fading Channel based on Fountain Code

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Abstract:

Nowadays, the video calling, video on demand (VOD) and more services are desired for users. These services generate large traffic which requires special techniques for transmission without outages or failure during transmission operation. Fountain Code is the newest method in the encoding theory and it is handle designed to large data. Besides, modern MIMO channel gives higher capacity than traditional channel (SISO channel). This paper looks out of the performance of Fountain Code on MIMO Scheme under Slow Fading Channel. The results show the performance is the best on MIMO (DF). In addition, the performance increases by increasing in the number of receiver antennas.

Keywords: Fountain Code, Luby Transform, Cooperative MIMO, Slow Fading, Bit Error Rate, Decode and Forward (DF).

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1. Introduction

Today›s video calling becomes an important issue in communication world that generates a very large data [1]. The traditional system of communication has one antenna in both transmitter and destination, which contains one path from the transmitter to the receiver. This system is called Single Input Single Output (SISO) system [2]. However, SISO does not work well with high traffic services. This is because the link capacity is not enough. This can cause outages in communication. To overcome the outages, MIMO (Multi Input Multi Output) system is invented by Alamouti at 1998 [3]. MIMO systems enhance diversity by sending copies of a message to the destination and the data rate is increased during transmission by dividing message frames or symbols regarding the number of transmission antennas. This operation allows to send large data on one slot time and decreases occupying capacity of the channel[4]. Furthermore, the old techniques in channel coding or Forward Error Correction (FEC), have invented to recover message on the destination without needing to retransmits or feedback channel between sender and destination. However, these techniques are not suitable for large data without dividing data into small parts. Hence, a new coding technique that is suitable for large data is needed. Rate Less Code (RLC) concept realizes this issue has been introduced by John Byres [5]. Fountain Code (FC) can be considered as a first class that utilizes this concept. Luby Transformer (LT) is a first code belong to FC, which is invented by Luby at 2002 [6]. Patil [7] has studied transmission of large data in Additive White Gaussian Noise (AWGN) channel over MIMO-OFDM in 4G-LTE. Andrei and Nicolau [8] have studied the performance of transmission large data in MIMO 2x2 fading by Space-Time Block Code (STBC) Code. Johnsi and Saminadan [9] have studied the performance of ddiversity ccombining ttechniques for Free-Space Optical MIMO (FSO-MIMO) system for LDT.

2. Problem Statement

Currently, the transmission of large data communication systems is very important. The large data is resulting from rapidly growing of wireless data service like video calling, video streaming, online music, online broadcast (TV, radio)……etc.

It is expected that the mobile data traffic is increasing by five times from 2015 to 2020 [10]. Originally, Fountain Code (FC) is designed for working at erasure channel like computer networks. The performance of FC is increased by growing the size of data [11].

Many techniques have been proposed to deal with large data. Borrayo et al at their work [12] have introduced a configurable interleaved architecture for the turbo decoder in 3rd Generation Partnership Project (3GPP). They present a fully functional 3GPP Turbo code (TC) interleave/deinterleave architecture that receives an input data stream of any size established by the 3GPP standard. Hensel et al [13] have used Gilbert-Elliott channel (GEC) as a mathematical model for performance of coding and transmission schemes in the context of burst erasure channel (EC) conditions. Hsin-Ta et al [14] have studied a new ideal AL-FEC (Application-Layer FEC) for mobile TV streaming over mobile Worldwide Interoperability for Microwave Access (WiMAX).

As mentioned in section I, MIMO is a useful method to transmit large data without outages theoretically and overcome fading effects which are resulting in channel link. In this case, two nodes, sender, and destination are used. Cooperative methods are an also useful method to improve data transmission operation by using partner when transmission operation. By merging between two techniques MIMO and Cooperative, techniques a new technique is created which is called Cooperative MIMO (C-MIMO) [15]. In this case, three nodes are used, sender, relay, and destination. Through knowing the properties of MIMO, C-MIMO, and FC, the increasing in the performance of communication system to transmit a large data is expected.

The rest of this paper is divided into six sections. Section 3 introduces Fountain Code, Sections 4 and 5 comes in with a brief description to MIMO, C-MIMO. Section 6 explains the methodology of the experiments. Section V7 shows the Results obtained with the discussions. Finally, Section V8 gives the conclusions and future works.

3. Fountain Code

In traditional Forward Error Correction (FEC), the code rate is fixed and destination must receive all sent code word to decode it and reconstruct the original message. Fountain codes are a first practical rateless code. The property allows the encoder to encode message without fixed rate. Fountain code concepts are produced by Byers et al. in 1998 [5]. The concept is based on a fountain spraying water drops, which then are collected into a bucket. Figure 1 shows the concept. Fountain Code is suited for sending information over computer networks. A source sends data to many destinations like a fountain; all destinations can recover source data from the minimal possible encoding. Luby Transform (LT) is the first class of fountain code, is produced by Luby at 2002 [6].

3.1 Luby Transform (LT)

The first class of Fountain Code is Luby Transform (LT), which invented by Michael Luby who introduced it at 2002 [6]. LT codes generate the infinite number of output symbols by encoding a finite number of message symbols. The important key of LT is a degree distribution that makes LT code work well in practice. The important key of LT is a degree distribution that makes LT code work well in practice.

The degree of encoded bit is determined by the Following equations:

$$\rho(d) = \begin{cases} 1/K & K = 1 \\ 1/(K-1) & K = 2,..K \end{cases} \quad (1)$$

$$\tau(d) = \begin{cases} R/dK & d = 1,....round(K/R)-1 \\ R\ln(R/\delta)/K & d = round(K/R) \\ 0 & else \end{cases} \quad (2)$$

$$Z = \sum_d \rho(d) + \tau(d) \quad (3)$$

$$\mu(d) = \frac{\tau(d) + \rho(d)}{Z} \quad (4)$$

Where:

K The size of the message.

$\rho(d)$ The Ideal Soliton distribution (ISD).

$\tau(d)$ The Robust Soliton Distribution (RSD).

$\mu(d)$ The degree of encoded bit

δ The is allowable or tolerable failure probability.

$$R = c.\ln(K/\delta).\sqrt{K}$$

c is a constant which controls the average of degree distribution. The value of is 0.2 which using in practical application [11].

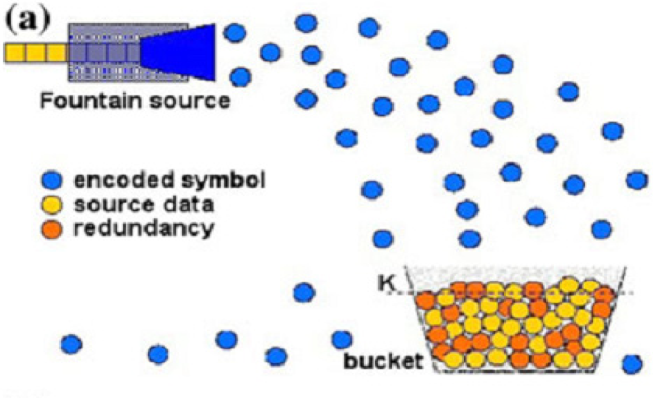

Figure (1): Fountain Code Concept

4. MIMO

The MIMO term is an abbreviation for Multi Input Multi Output that means, in communication world, all nodes on communication system have two antenna at least. MIMO is classified by kind of the data transmission to the spatial diversity or the simply diversity and the spatial multiplexing. In the diversity, the data is copied according to the number of the transmission antenna, and in the spatial multiplexing, the data transmission is dived into parts according to the number of transmission antenna. The diversity improves reliability and the multiplexing increase data rate. Figure 2 shows two nodes and each node has three antenna.

5. C-MIMO

In this system, an additional node is added which is called a partner or relay. In this case, three cases are being by the occupation of partner or relay, Apply and Forward (AF), Decode and Forward (DF) and Coded Cooperative Forward (CCF). Figure 4 shows C-MIMO system.

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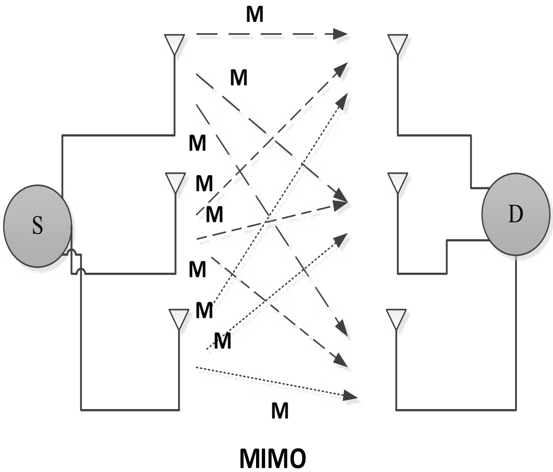

Figure (2): MIMO System

The phases of transmission in C-MIMO are shown in Table 1.

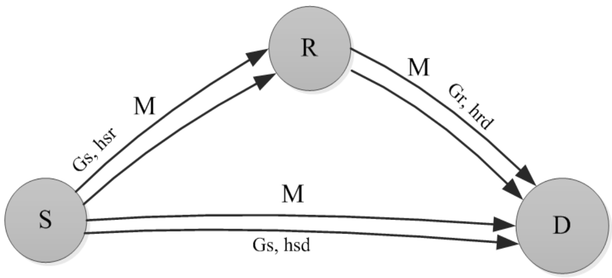

Figure (3): C-MIMO System

Table (1): Phases in Cooperative

Phase 1	t1	$S \rightarrow R, D$
Phase 2	t2	$R \rightarrow D$

From Table 1, in phase 1(t1) sender sends data to relay and destination simultaneously, relay be comes in silencing mode (do not send data); in phase 2 (t2) relay send data to destination and sender be come in silencing mode (do not send data).

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6. Methodology

The Methodology of this paper contains three steps as described below:

The First step is studying the performance of FC on MIMO 2x2 and chooses it as reference study. The operation sequences, in the sender and the destination, are shown in Figures 4 and 5.

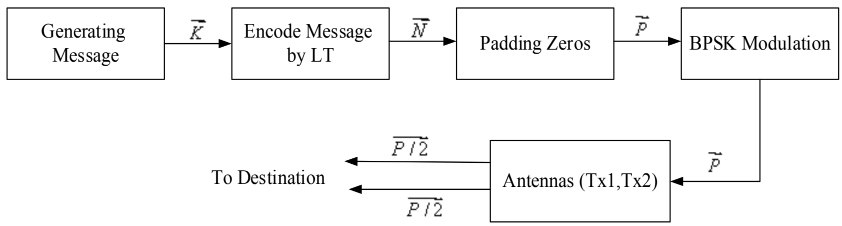

Figure (4): Operation Sequences in Sender

The Second step is studying the performance of FC on MIMO 2x8.

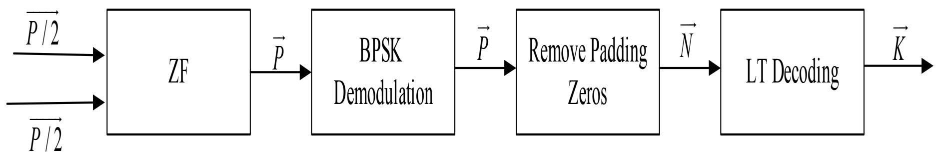

Figure (5): Operation Sequences in Destination MIMO

The Third step is studying the performance of FC on C-MIMO (DF) 2x8. This paper adds stages to the design which Nosratinia decided[17]. The additional stages are added in the relay which are decoding stage and encoding stage.

7. Results and Discussions

Table 1 contains the values of Bit Error rate (BER), for MIMO 2x2, MIMO 2x8 and C-MIMO (DF) 2x8, versus multi-values of Eb/No in decibels. This Table is ne represented graphically, as in Figure 9. The results show the performance of FC is bad in the case MIMO 2x2, but it improves with increasing the number of receiving antennas to 8.

The MIMO 2x8 (DF) gives the best performance. The value of BER equals nearby zero at 0- 2 dB and equals zero at 3db. The results of the case MIMO 2x8 (DF) prone that it is suitable for channels that have negative values of Eb/No or the power of the noise signal is greater than the power of transmitted signal.

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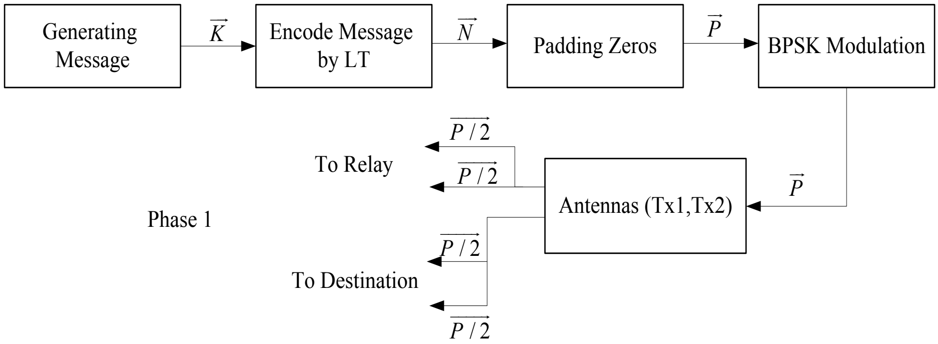

Figure (6): Operation in Sender MIMO (DF)

Table (2): BER of MIMO 2x2, MIMO 2x8 and C-MIMO 2x8 (DF)

Eb/No(dB)	BER		
	MIMO 2x2	MIMO 2x8	C-MIMO (DF) 2x8
0	0.4536	0.2789	0.0030
1	0.4467	0.2146	0.0004
2	0.4382	0.1513	0.0007
3	0.4302	0.0991	0
4	0.4186	0.0466	0
5	0.4097	0.0298	0
6	0.3983	0.0104	0
7	0.3877	0.0062	0
8	0.3738	0.0032	0
9	0.3600	0.0018	0
10	0.3462	0.0005	0

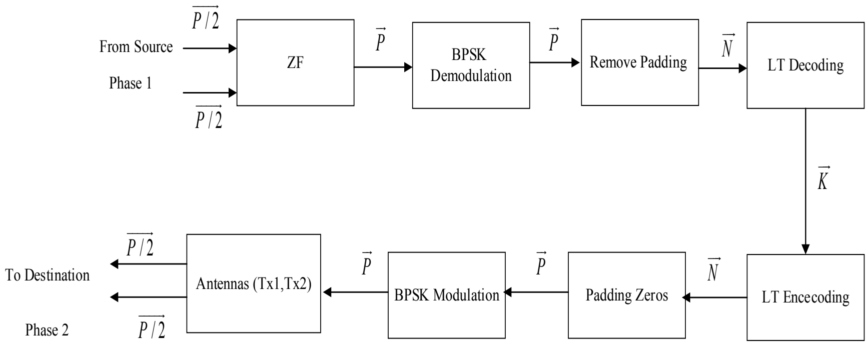

Figure (7): Operation in Relay MIMO (DF)

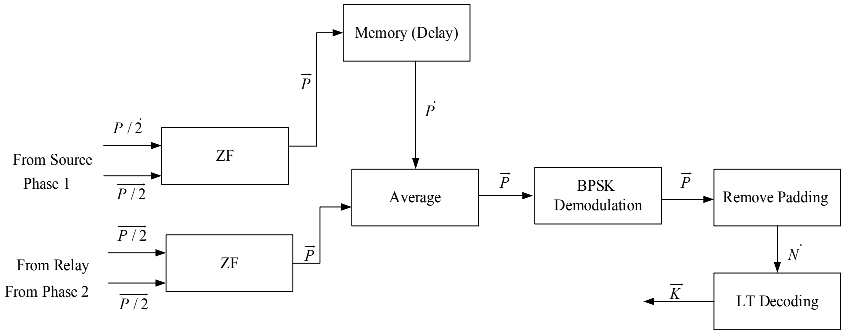

Figure (8): Operations in Destination MIMO (DF)

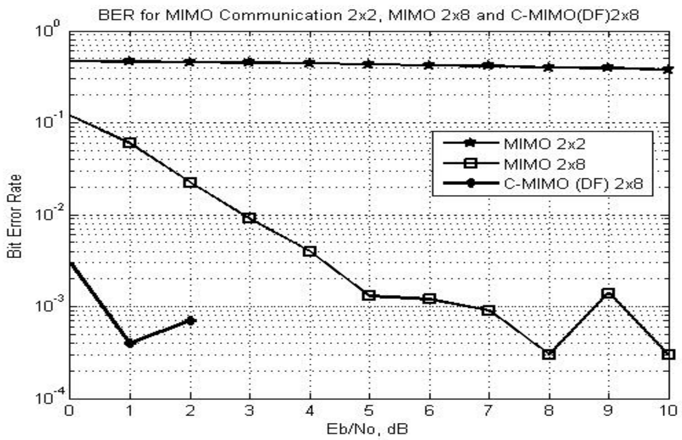

Figure (9): BER of MIMO 2x2, MIMO 2x8 and C-MIMO 2x8 (DF)

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8. Conclusion and Future works

This paper shows the performance increases by growing in the number of antenna receivers. The FC is used for encoding large or big data. MIMO and C-MIMO are used for transmission multiplexing mode, which are more suitable for large data. Also, the result shows the MIMO (DF) 2x8 is the best case for Large Data Transmission (LDT).

However, the number of antennas are stills large. So an improvement in FC; to make it work well on MIMO with the least number of antennas is needed. This paper used one relay with C-MIMO. Further investigation is needed to study the performance of C-MIMO with multi-relays. The study of the performance of another class of FC (Raptor code and RaptorQ code) is also needed.

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