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Improvement of Channel Capacity in a Multiple input Multiple Output LTE Radio System for GSM-Users Using Ideal Power Distribution Technique

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ABSTRACT

Demand for high data rate in recent times has led to the development of LTE technology. There has been an increase of downlink and uplink speed of radio mobile communication to 10 M bps and 50 Mbps respectively. As mobile subscribers keep increasing, there is a need to enhance bandwidth for adequate data transmission. This study focused on the application of the MIMO system to enhance channel capacity by allocating more power to subchannels with better signal to noise ratio (SNR). The adaptive iterative water-filling technique was proposed and compared with other system capacity enhancement techniques such as conventional water filling and equal power allocation techniques by in incorporating the effect of path loss in wireless communication network The results presented show that incorporating path-loss model of LTE systems in the bands of 1800 MHz and 2500 MHz improves the MIMO system capacity. Also, increased in antenna size both at the transmitter and the receiver enhances the system capacity tremendously.

Keywords: Power, MIMO, Capacity, SNR.

1.0 INTRODUCTION

The tremendous rise in the usage of wireless network services and the demand for higher data rate has led to the development of Long Term Evolution (LTE) technology. LTE is the most current standard technology in the mobile network hierarchy that was able to achieve the GSM/EDGE and also UMTS/HSPA technologies [1]. The awareness of LTE resulted in the designed and deployment of the 4th generation radio technologies commonly refer to as 4G in order to enhance capacity as well as the data rate of the existing 3G radio technology [1]. Although LTE has taken the major role in the design of 4G mobile communication networks, wireless network service providers are still striving towards achieving more throughputs from the existing bandwidth. The downlink and uplink speed of radio mobile

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communication has increase to 100 Mbps and 50 Mbps respectively due to the growing of LTE technology [1]. LTE supports bandwidths from 1 MHz to 20 MHz and also supports both Time Division Duplexing (TDD) and Frequency Division Duplexing (FDD). This data rate can be enhanced additionally through the application of multiple input and multiple output (MIMO) system [2]. MIMO systems are known to be a special class of wireless systems which has multiple antennas at both transmitter and receiver. Its purpose is to create some diversity within the network and employ channel coding method for transmission.

The benefit of having multiple transmit antennas is to ensure data rate is enhanced by transmitting several packets of data in parallel by means of the same time, frequency and transmit power. MIMO's ability to achieve high data rate in data transmission over wireless system has inspired practical interest of researchers [2]. One of the major challenges of MIMO system is the extra high cost of Radio frequency modules which are needed due to limited supply from electromagnetic spectrum [2]. A good number of researchers have carried out research on capacity enhancement in WCDMA wireless radio network but few have been done on Long Term Evolution (LTE). [2] worked on the improvement of spectral efficiency of wireless fading channel using space diversity techniques in MIMO system. The Author's results shows that signal quality at the receiver increases with the execution of different diversity techniques in MIMO system as shown in Figure 1.1.

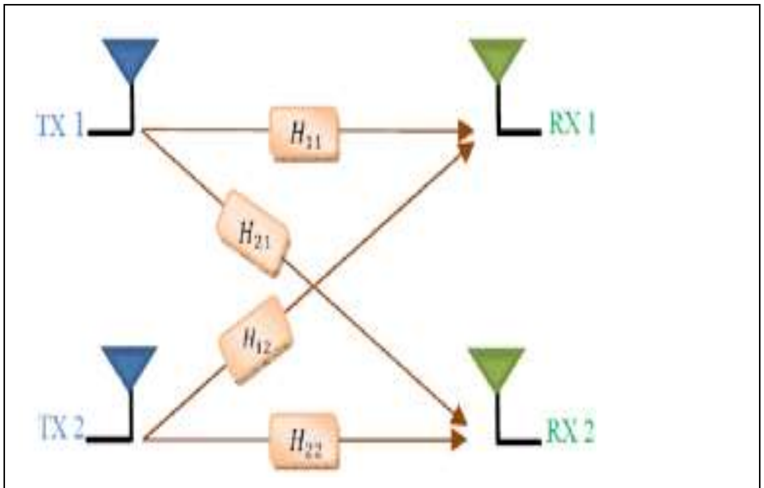

Figure 1.1 Example OF 2x2 Mimo System

Jaafar, A., et. al. [2] also studied the performance analysis of Rayleigh fading channels in MIMO-OFDM systems using BPSK and QPSK modulation schemes. They discovered that BER using BPSK reduces when compared with the QPSK scheme which in turns increases the capacity of the channel. [3] studied and analyzed the performance of conventional diversity techniques in Rayleigh fading channel. They adopted three dissimilar diversity techniques such as maximal ratio combining, equal gain combining and selection diversity. They observed that at different values of SNR with different numbers of antenna for all the three techniques, the maximal ratio combining revealed the best result as compare to other diversity techniques. [3-4] examined three different diversity techniques to mitigate fading in WCDMA. They also discovered that maximal ratio combining gives high diversity gain and high signal to noise ratio compare to other diversity techniques.

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Figure 1.2 Traffic per month

Jayanta,P. [3] also examined LTE systems with MIMO. The Author analyzed the throughput capacity of LTE down-links using both transmission and spatial multiplexing diversity techniques. In his research work, comparison between MIMO and SISO was carried out in terms of their bits error rate (BER) performance against the SNR of the LTE system. It was discovered that the performance of LTE with MIMO technology was verified to be better compared to SISO. Numerous studies have been conducted on LTE with MIMO system using diversity and spatial multiplexing techniques to increase the performance of the network, but only a few focused on LTE wireless network channel capacity [4-5]. Clearly, if the channel state information (CSI) is known it will then be easier to determine which sub-channels that can be allocated high power so as to increase the channel capacity. This has been a major setback in the telecommunication industry. In the meantime, the main focus of service providers is not only to provide data services to mobile users but, also to supply high capacity and data rate within the same bandwidths. In order to meet up with this pressing demand, there is need for a more suitable management of the available resources.

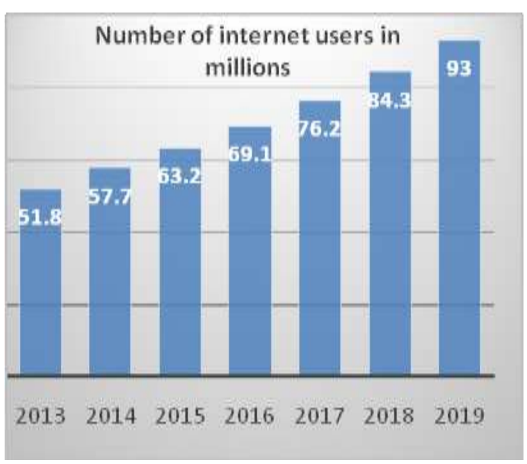

Figure 1.3 Internet users

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1.1. AIMS AND OBJECTIVES OF RESEARCH

- The main aim of this research work is to analyze MIMO channel and enhance the system capacity using Adaptive Iterative water filling (AIWF) technique. The objectives are:
- To employ AIWF technique to analyze MIMO systems channel of LTE radio network.
- To compare the mean capacity in bps/Hz of MIMO systems channel configurations using the AIWF technique at different SNR.
- To compare the AIWF technique with other system capacity enhancement techniques such as Conventional Water Filling and Equal Power Allocation techniques by incorporating the effect of path loss in wireless communication network.
- To learn representations of the input that captures the salient characteristics of the input distributions, algorithms, which can implicitly learn the distribution function of the observed data.

2. 0. METHODOLOGY

In this study, MIMO system with Adaptive Iterative water filling technique (AIWF) will be adopted to determine the channel capacity of SISO and MIMO systems. This research only considers Adaptive Iterative water filling algorithm (AIWF) because of its high effect and multilevel iterative approach in MIMO-LTE radio systems.

Adaptive Iterative water filling algorithm is the method of allocating power to sub-channels without neglecting noise influence. In this algorithm, the water level has to be adaptive for different sub-channels in order to determine the channel state information (C.S.I).

In water filling algorithms, more power is allocated to a sub-channel with low or better signal to noise ratio (SNR), in order to maximize the resources available and also increase the channel capacity of the system [5-7].

2. 1. EQUAL POWER ALLOCATION METHOD

This technique allocates equal to subcarriers irrespective of their channel state information (CSI) at that particular time [5-7]. For instance if we have M number of channels available for communication and transmit power p_t therefore the allocated power to each channel will be given by $\frac{p_t}{M}$. Therefore inorder to determine the capacity for various MIMO configurations, the allocated power to each subcarrier can be estimated from equation 1

$W_L = \frac{p_t}{M}$	(1)

Therefore the system capacity can be computed from equation 2.

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$C_m = \sum_{k=1}^{k} \log_2(1 + //h//^2 * P_{a(k)})$	(2)

Where *k* denotes the number of users and *h* is the channel gain

2. 2. CONVENTIONAL WATER FILLING METHOD

In this technique, each subchannel level noise is determined which shows the CSI in order to allocate optimum power to less noise subchannel [5], unlike the equal power method.

$W_L = P_t + \sum_{k=1}^{k} \frac{1}{h(k)}$	(3)

Where W_L repreesents water level, P_t denotes total power budget, $h(k)$ is the individual channel gain.

$P_{a(k)} = \frac{P_t + \sum_{k=1}^{k} \frac{1}{hkjd}}{M} - \frac{1}{hk}$	(4)

Where $P_{a(k)}$ is the allocated power to individual channel

$C = \sum_{k=1}^{k} \log_2(1 + P_{a(k)} * h)$	(5)

2. 3. PROPOSED ADAPTIVE ITERATIVE WATER FILLING METHOD

This algorithm is a method of allocating optimum power sub-channels taking noise levels into consideration. In this algorithm, the water level is first determined which is set as the threshold in which each subchannel noise level will be compared with. In this algorithm, optimum power is assigned to a subchannel with better signal to noise ratio to maximize the available resources and also enhance the system capacity.

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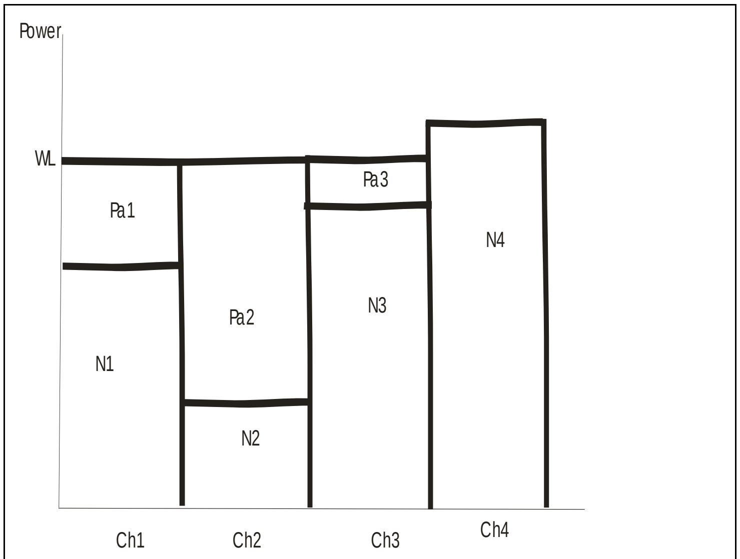

Figure 2.2 Proposed Adaptive Iterative Water Filling Technique

Path loss for cost 231Hata model for LTE systems in the bands of 1800MHz and 2500MHz as shown in equation 6

$$L_k = 128.1 + (37.6\log_{10} d)dB \qquad (6)$$

$$S_k = 10^{x(k)} \qquad (7)$$

Where $X_k \sim N(0,1)$ and Eigen value of the subchannel is shown in equation 7

$$Q_{j,k}(d) = L_k * S_k * h_{kjd} \qquad (8)$$

Water level is used to allocate optimum power for an active user, k as shown in equation 9

$$W_l = \frac{1}{k}\left[P_t + \sum_{k=1}^{k} \frac{N_o}{LS_{k(d)}}\right] \qquad (9)$$

The allocated power to an active user k according to large scale fading L_S is

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$$P_{a(k)} = \frac{1}{k}\left[W_L - \frac{N_O}{L_{S(d)}}\right] \tag{10}$$

Substituting equation 9 in 10 gives:

$$P_{a(k)} = \frac{1}{k}\left[P_t + \sum_{k=1}^{k}\frac{N_O}{LS_{k(d)}}\right] - \frac{N_O}{L_{S(d)}} \tag{11}$$

The allocated power to a subchannel d having power gains h_{kjd} with water level of user, k is

$$W_{l(k)} = \frac{1}{M}\left[P_{a(k)} + \sum_{d=1}^{M}\frac{N_o}{h_{kjd}}\right] \tag{12}$$

Therefore, the allocated power to the subchannel d is given as :

$$P_{a(j,d)} = W_{l(k)} - \frac{1}{h_{kjd}} \tag{13}$$

Substituting equation 12 in 13 gives:

$$P_{a(j,d)} = \frac{1}{M}\left[P_{a(k)} + \sum_{d=1}^{M}\frac{N_o}{h_{kjd}}\right] - \frac{1}{h_{kjd}} \tag{14}$$

Also, substituting equation 11 in 14 gives:

$$P_{a(j,d)} = \frac{1}{Mk}\left[P_t + \sum_{k=1}^{k}\frac{N_O}{LS_{k(d)}}\right] - \frac{N_O}{ML_{Sk(d)}} + \frac{1}{M}\sum_{d=1}^{M}\frac{N_O}{h_{kjd}} - \frac{1}{h_{kjd}} \tag{15}$$

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2.4 MIMO System Capacity

The sum capacity of user k, is given as:

$$C_k = \sum_{j=1}^{/k/} \sum_{d=1}^{Q_{j,k}} (\log_2 (1 + \frac{P_{a(j,d)} * Q_{j,k}(d)}{N_O w})) \qquad (16)$$

Hence, the MIMO system capacity when all active user's capacity are added gives :

$$C_{system} = \sum_{k=1}^{k} \sum_{j=1}^{/k/} \sum_{d=1}^{Q_{j,k}} (\log_2 (1 + \frac{P_{a(j,d)} * Q_{j,k}(d)}{N_O w})) \qquad (17)$$

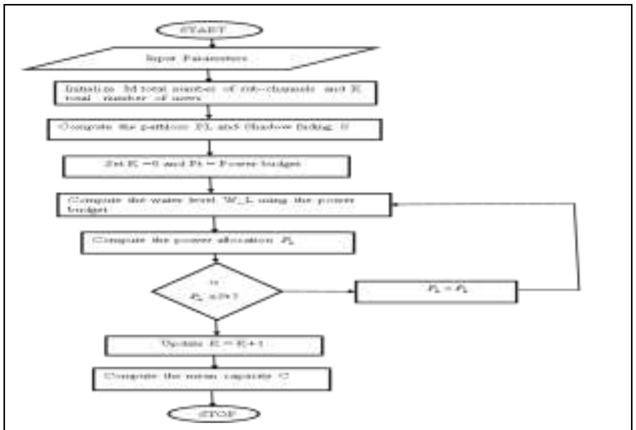

Figure 2.1 The AIWF Algorithm

3.0 RESULTS AND DISCUSSION

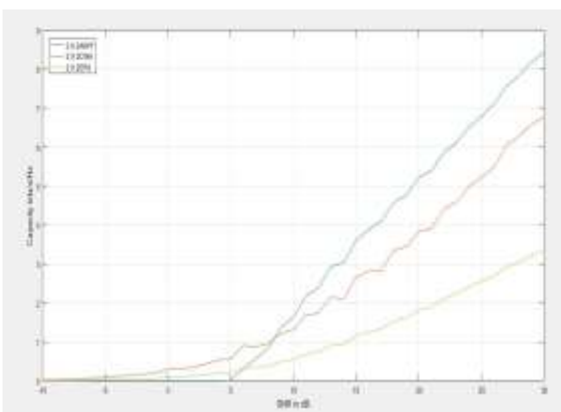

Figure 3.1. Capacity of 2x2 MIMO mode with respect to the SNR for EPA, CWA and AIWF techniques.

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Figure 3.1 shows the capacity of 2x2 MIMO with respect against SNR for the techniques considered. The proposed technique performs better in terms of capacity as SNR increases. At 20dB, the proposed technique attained a capacity of 5 Mbps while others are much lower.

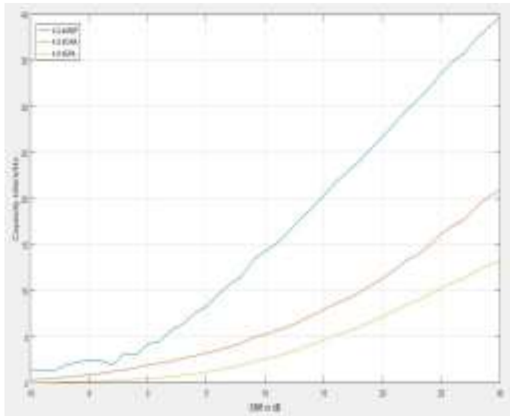

Figure 3.2. Capacity of 4x4 MIMO mode with respect to the SNR for EPA, CWA and AIWF techniques.

Figure 3.2 shows the capacity of 4x4 MIMO with against SNR. The proposed technique performs better in terms of capacity as SNR increases. At 20dB, the proposed technique attained a capacity of 26 Mbps (much lower)

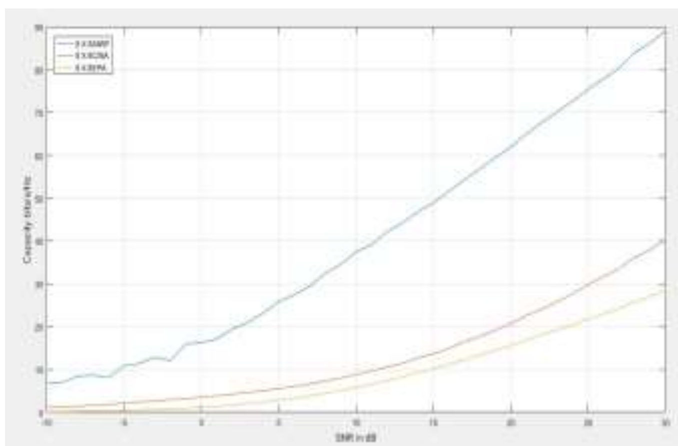

Figure 3.3. Capacity of 8x8 MIMO mode with respect to the SNR for EPA, CWA and AIWF techniques.

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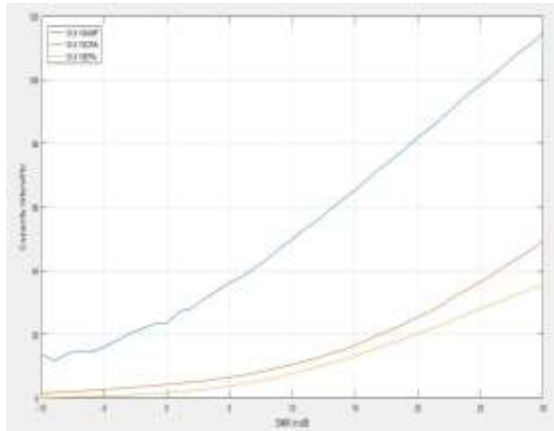

Figure 3.4. Capacity of 10x10 MIMO mode with respect to the SNR for EPA, CWA and AIWF techniques.

Figure 3.3 and 3.4 shows the capacity of 8x8 and 10x10 MIMO against SNR. The proposed technique performs better in terms of capacity in both cases as SNR increases. At 20dB, the proposed technique attained a capacity of 60 Mbps and 80 Mbps while others are much lower

4.0 CONCLUSION

This study presents the enhancement of MIMO systems capacity in LTE wireless network using AIWF technique which is based on optimal power allocation to each sub-channels with better channel gain. Furthermore, Equal Power Allocation (EPA) and Conventional Water Filling (CWA) techniques were employed as comparison with the proposed AIWF technique. At the end of the analysis as the results rightly indicated, it can be concluded that AIWF technique is more efficient in LTE MIMO system capacity enhancement compared to other two strategies investigated.

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