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The Impact of Transmit Diversity in LTE-A Capacity

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Abstract: ***Transmitter using diversity technology to increase signal quality and reduce the error in the received signal by send the same data across a number of antennas number of copies of data across more than one antenna. In this paper we aims to study the impact of Transmit Diversity on capacity for the Long Term Evolution-Advanced for normal cyclic prefix in spectrum allocation of (25, 30, 35, 40 and 100) MHz The capacity calculations will take into account the effect of the correction factor (losses due to cyclic prefix and reference symbols). The result of study will determine whether the transmit diversity meet the requirement of IMT-Advanced that identify by The ITU in terms of capacity at acceptable value of SNR and analyze the effect of the number of antennas in capacity when using transmit diversity.***

Keywords: MIMO, LTE-A, Transmit Diversity, capacity

1. Introduction

The limitation of bandwidth and the rapid growth of users and the continuing need to increase the data rate Led to very fast development in wireless communications systems in the past two decades, through the provision of different generations 2G 3G and 4G which now reached the LTE-A

LTE-A is a part of the 3GPP standards, in addition to the use of MIMO and OFDM it introduced many changes and improvements.

LTE-A aims to improve spectral flexibility, increase data rates, improved coverage and increase battery life time [1].

Bandwidth is one of the most important success factors in the wireless communications for that the 3GPP introduced carrier aggregation to increase bandwidth while maintaining compatibility with LTE r8, r9 and ensure high data rates to meet the voice and video transmission[2] The capacity determine the quality of the communication systems at the end user[3].

In September 2009 the 3GPP Partners made a formal submission to the ITU proposing that LTE Release 10 & beyond (LTE-Advanced) should be evaluated as a candidate for IMT-Advanced.

In October of the year 2010 lte-a successfully passed the evaluation process and has been adopted As a standard for the fourth generation that achieves the ITU standard that defines the requirements must be available in the mobile systems that are part of or exceed the capabilities of IMT- 2000 or IMT-Advanced (International Mobile Telecommunications) the most important requirements of IMT-Advanced increase the data rates. In order to support advanced services and applications 100Mbps for low for low and 1Gbps for high mobility scenarios. [4] In this paper we evaluate and compare the capacity in LTE-A for Transmit Diversity (TXD 2X1) and (TXD 4X2) for normal cyclic prefix by using aggregated Carrier (25, 30, 35, 40 and 100) MHz and analyze the effect of the number of antennas in capacity when using Transmit Diversity.

2. Transmit diversity (TXD)

In transmit diversity, redundant information (same data stream) is transmitted on different antennas.

2.1 Transmit diversity implements 2X1 (MISO)

Figure 1: Multiple Input Single Output (2X1)

2.2 Transmit diversity implements 4X2 (MIMO)

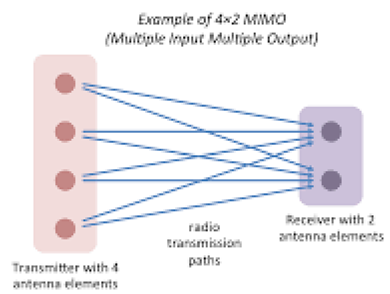

Figure 2: Multiple Input multiple Output (4X2)

3. Methodology

3.1 The general equation of Shannon's Channel Capacity:

Shannon derived the following capacity formula (1948) for an additive white Gaussian noise channel (AWGN) [5]

$$C = w\ log_2(1 + S/N) \qquad (1)$$

W is the bandwidth of the channel in Hz, S is the signal power in watts, N is the total noise power of the channel in watts.

3.2 capacity is[5]
3.3

$$C = F * B\ log_2(1 + SNR) \qquad (2)$$

Where F is the correction factor, B is the effective bandwidth and SNR is the signal to noise ratio.

3.4 The effective bandwidth is:

$$B = \frac{N_{sc} * N_s * N_{rb}}{T_{sub}} \qquad (3)$$

Where N_{sc}=12 is the subcarriers in one RB, N_s is the number of OFDM symbols in one subframe (14 for normal Cyclic Prefix (CP)), N_{rb} is resource block that fit into the selected system bandwidth (for example 125 RBs within a 25 MHz system bandwidth) and T_{sub} is the duration of one subframe equal to 1 ms. As it is illust For normal cyclic prefix the length of the first symbol is 5.2 microseconds while for the other six symbols the length is 4.7 microseconds.

3.5 correction factor

$$F = \frac{T_{frame} - T_{cp}}{T_{frame}} * \frac{N_{sc} * \frac{N_s}{2} - R}{N_{SC} * \frac{N_s}{2}} \qquad (4)$$

The first part of the above equation represents the cyclic prefix loss in which T_{frame} is the fixed frame duration equal to 10 ms. And T_{cp} is the total CP time of all OFDM symbols within one frame. And the second part represents the reference symbols loss where R is the number of resource elements (RE) that carries the reference symbols in the antenna port, (Reference Signal (R) is provided to enable the User Equipment (UE) to estimate the radio channel).

4. Transmit diversity (2X1):

4.1 the capacity for transmit diversity 2X1 is:

$$C_{TXD\ 2X1} = F_1 * B\ log_2(1 + SNR) \qquad (5)$$

4.2 the correction factor is:

$$F_1 = \frac{T_{frame} - T_{cp}}{T_{frame}} * \frac{N_{sc} * N_s/2 - R_1}{N_{sc} * N_s/2} \qquad (6)$$

and R_1 is the number of reference symbols for two antenna ports which is shown in figure 3

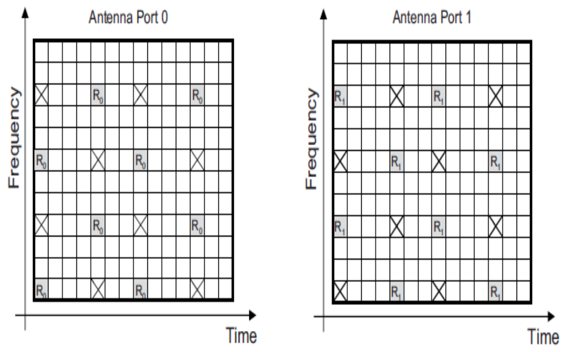

Figure 3: Cell-specific RS arrangement in the case of normal CP length for two antenna ports [6]

5. Transmit diversity 4X2

4.3 The capacity for transmit diversity 4X2 is:

$$C_{TXD\ 4X2} = F_2 * B\ log_2(1 + SNR) \qquad (7)$$

4.4 Transmit diversity 4X2 the correction factor is:

$$F_2 = \frac{T_{frame} - T_{cp}}{T_{frame}} * \frac{N_{sc} * N_s/2 - R_2}{N_{sc} * N_s/2} \qquad (8)$$

and R_2 is the number of reference symbols for four antenna ports as in figure 4

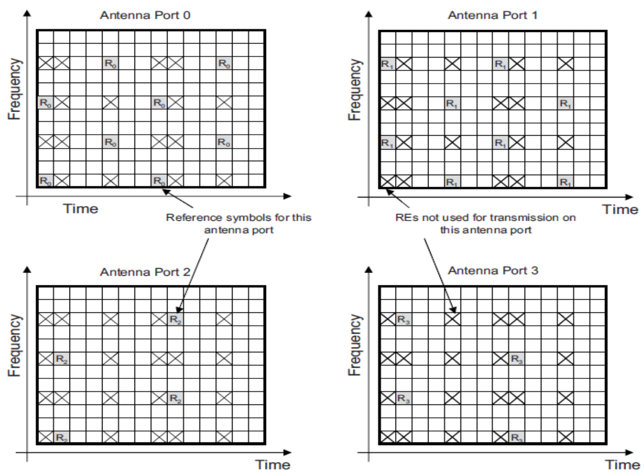

Figure 4: Cell-specific RS arrangement in the case of normal CP length for four antenna ports [6]

6. Simulation Results

The MATLAB program used to represent the relation between Signal to Noise ratio and capacity and give a curve in In the X and Y axes to shows the relationship by using the bandwidth (25.30, 35, 40 and 100) MHz and the results were as in the following figures of (5 to 9):

6.1 Simulation figures:

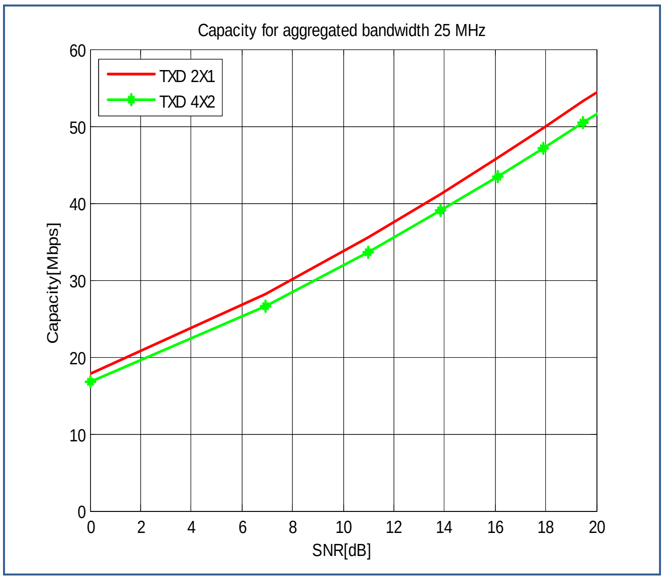

Figure 5: Capacity for 25 MHz

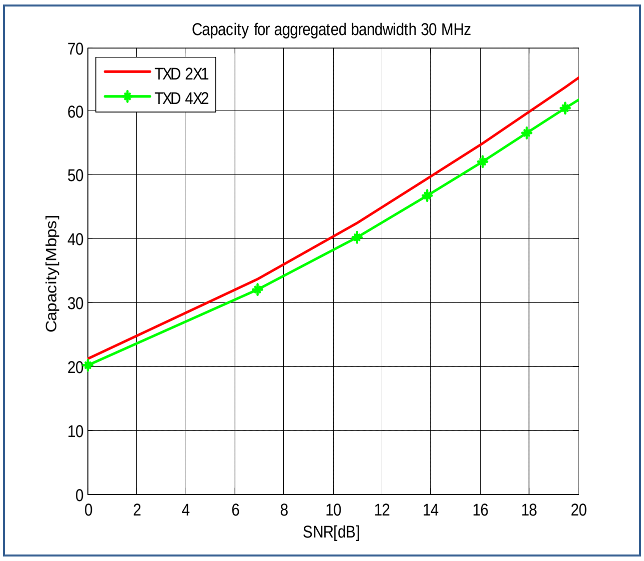

Figure 6: Capacity for 30 MHz

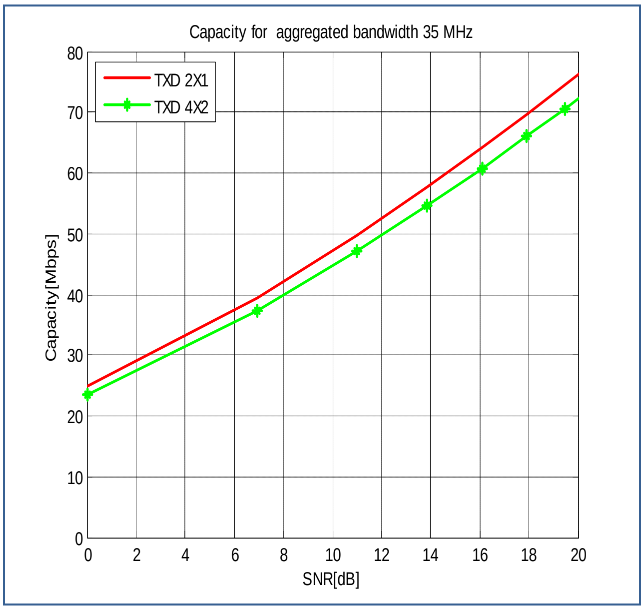

Figure 7: Capacity for 35 MHz

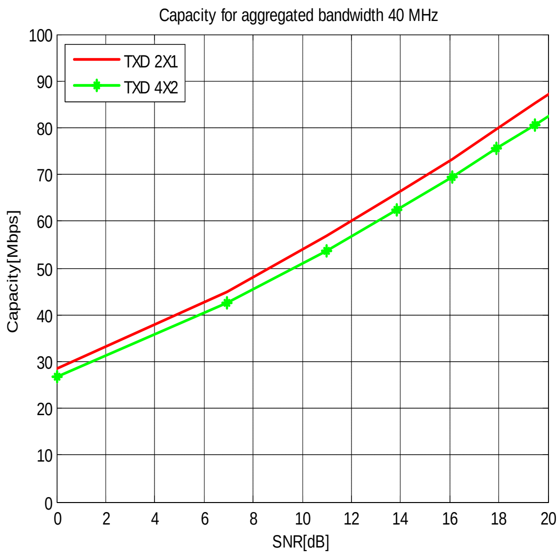

Figure 8: Capacity for 40 MHz

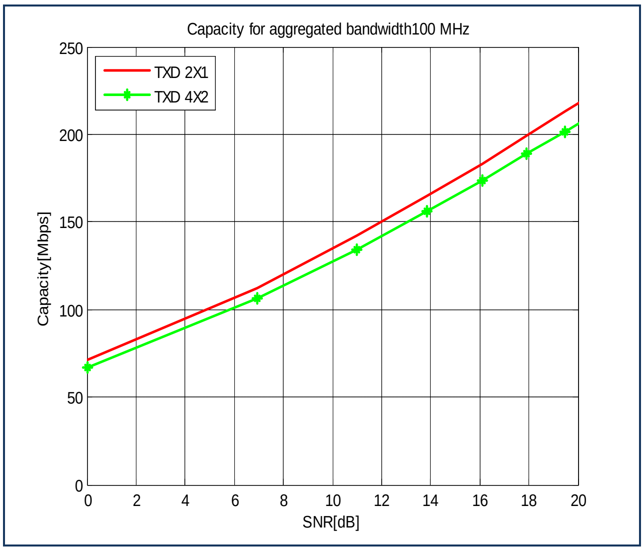

Figure 9: Capacity for 100 MHz

6.2 Capacity analysis :

Table 1 describes capacity the results shows that TXD 2X1 gives highest capacity over TXD 4X2.

In the table a comparison is made between the two capacities at 20 SNR

Table 1: Capacity comparison in Mbps for TXD (2X1) and TXD (4X2) in all bandwidth

Number of antennas	Capacity at SNR 19.46 dB
25 MHz	
TXD (2X1)	53.19
TXD (4X2)	50.39
The difference	2.8 Mbps
30 MHz	
TXD	63.83
TXD (4X2)	60.47
The difference	3.36 Mbps
35 MHz	
TXD (2X1)	74.47
TXD (4X2)	70.55
The difference (in Mbps)	3.92 Mbps
40 MHz	
TXD (2X1)	85.11
TXD (4X2)	80.63
The difference	4.48 Mbps
100 MHz	
TXD (2X1)	212.8
TXD (4X2)	201.6
The difference	11.6 Mbps

7. Conclusion

For the capacity analysis for transmit diversity (2X1) versus transmit diversity (4X2) in LTE downlink, in all transmission bandwidths (25, 30, 35, 40 and 100) MHz for normal cyclic prefix, the simulation results show that transmit diversity (TXD 2X1) has the highest capacity over transmit diversity (TXD 4X2).

We found that, increasing in number of antennas for the transmit diversity mode reduces system capacity in all available bandwidth in LTE-A because we transmit the same data over all antennas and the process added by new antennas will increase the overhead in system.

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