A Comparative Performance Analysis of Spatial Multiplexing and Transmit Diversity Approaches for 2X2 LTE Correlation based Channel

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ABSTRACT
Multiple Input Multiple Output (MIMO) systems form an essential part of LTE in order to achieve the striving requirements for throughput and system robustness. In Long Term Evolution (LTE), MIMO technologies have been broadly used to get better downlink peak rate, cell coverage, as well as average cell throughput. To achieve these goals, LTE adopts two major MIMO technologies i.e. Spatial multiplexing (SM) and transmit diversity (TD) to offer substantial benefits in terms of rate and reliability. There is an optimal tradeoff between Diversity and spatial Multiplexing gain, which is indication of rate and probability of error. This paper will show throughput and Bit error rate performance with specific application to SM and TD in 2X2 LTE Correlation based channel environments. The effect of different environment conditions using correlation 2x2 MIMO channel model is determined describing how they relate to SNR and vehicular speed at LTE Receiver .The investigations reported in this paper helps in estimating the optimum switching conditions between two MIMO approaches for fixed antenna spacing at transmitter and receiver.

Keywords
MIMO, 3GPP LTE, SM, TD, BS, MS.

1. INTRODUCTION
Future wireless systems will employ multiple antennas at both transmitter and receiver to improve quality, capacity, and reliability. The 3rd Generation Partnership Project (3GPP) recommends specifications of Long Term Evolution (LTE) [1]. The hybridization of Multiple input multiple output (MIMO) technologies with LTE has generated features such as spatial multiplexing and transmit diversity for better speed and efficiency to support future broadband data service over wireless links [2].

In Transmit Diversity a single stream of data is assigned to the different layers and coded using various methods for eg. Space Time Block Coding (STBC). STBC achieves robustness through temporal diversity by using different subcarriers for the repeated data on each antenna[3].Spatial multiplexing, on the other hand, is an approach where the incoming data is divided into multiple sub streams and each sub stream is transmitted on a different transmit antenna [4,5].

With the advent of MIMO, a choice needs to be made between transmit diversity techniques, which increase reliability (decrease probability of error), and spatial multiplexing techniques, which increase rate but not necessarily reliability [6]. Since practical systems make some trade-off between rate and reliability, it is unclear how to choose between spatial multiplexing or MIMO diversity for a given application. The present paper summarizes the studies undertaken pertaining to 2x2 MIMO for LTE Correlation Based channel. In this paper we consider the multiplexing-diversity tradeoff from the point-of-view of different environment conditions, with variation in SNR and vehicular speed.

2. SYSTEM OVERVIEW
A 2X2 MIMO LTE Correlation based channel is developed using various building Blocks of Agilent's SystemVue and its Channel Builder tools. LTE Downlink configuration for MIMO is assumed as baseline configuration, i.e. 2 transmit antennas at the base station and 2 receive antennas at the terminal side. The Correlation Based 2x2 MIMO Channel Model takes into account the correlation at the transmitter and receiver to determine the response of the channel using kronecker channel modeling method .

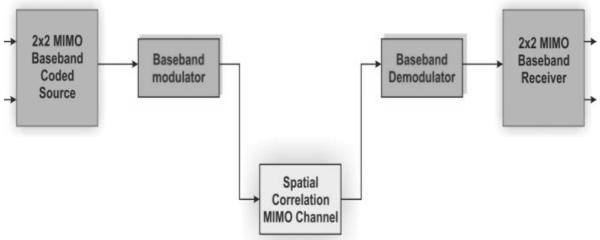

Fig 1. 2×2 MIMO Block Diagram

Channel bandwidth of 10 MHz with carrier frequency of 2.15 GHz is selected with FDD duplex scheme and OFDMA access scheme for downlink. The modulation type used is 16 QAM. Correlation channel with finite discrete multipath components which are considered to be uniformly distributed about the transmitter and receiver is used. Each multipath component is considered to be uncorrelated and characterize by angle of arrival, angular spread and path gain. Three multipath scenarios, first small office with poor scattering, second typical office with moderate scattering and third large office with rich scattering environment are considered. These channel power delay profiles are based on the clustering approach developed by Saleh and Valenzula [7].
The key parameters are tabulated below:

Table 1: System Parametrs

Parameter	Specification
System	SU – 3GPP LTE Downlink Channel
Mode	MIMO 2x2 Transmit Diversity mode/Spatial Multiplexing mode

Transmitting Antenna	Omni directional
Receiving Antenna	Omni directional
Frequency	2.15 GHz
Modulation Scheme	16QAM (½ Code rate), OFDMA
Detection scheme	MMSE
Rayleigh spectrum shape	Classical 6dB
XPER	-9dB
Vehicular Speed	20Km/hr
MIMO Channel Model	Correlation 2x2 Channel model
Channel Bandwidth	10 MHz
Transmit Power	10 dBm

In this paper the investigation being undertaken will help in estimating the throughput of such system with specific application to TD and SM in three different environments i.e, poor , moderate and rich scattered , describing how they relate to SNR and MSvelocity at LTE receiver and how they affect system performance along with the recommendation.The Throughput is carried out for various antenna spacing at different SNR with mobile receiver moving at different speeds.

3. RESULTS AND DISCUSSION

3.1 For BS Spacing 1λ and MS 0.5λ

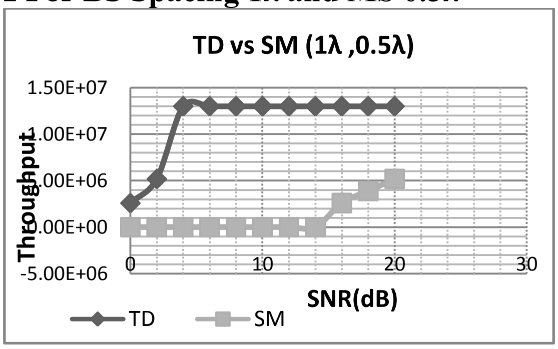

Fig 2. Throughput v/s SNR(1λ,0.5λ)

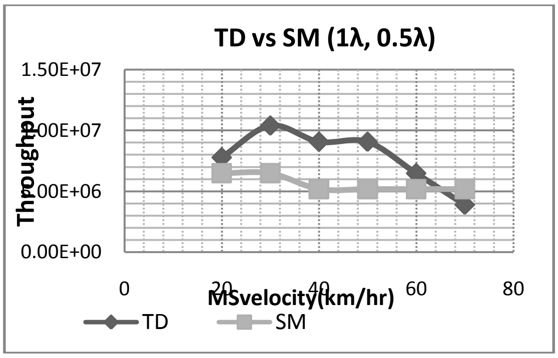

Fig 3. Throughput v/s MSvelocity (1λ,0.5λ)

3.2 For BS Spacing 2λ and MS 0.5λ

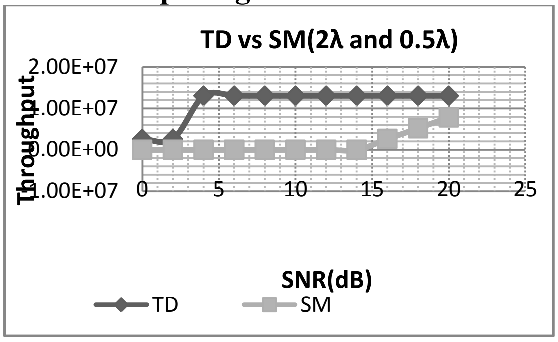

Fig 4.Throughput v/s SNR (2λ,0.5λ)

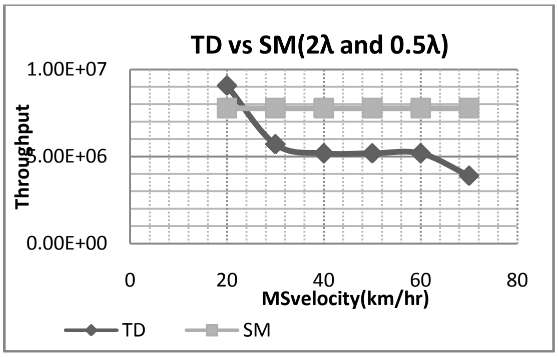

Fig 5. Throughput v/s MSvelocity (2λ,0.5λ

3.3 For BS Sspacing 3λ and MS 0.5λ

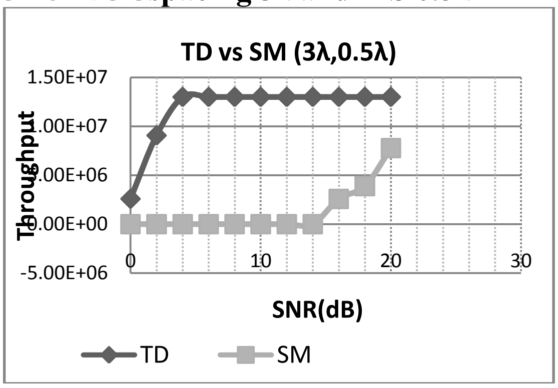

Fig 6. Throughput v/s SNR(3λ,0.5λ)

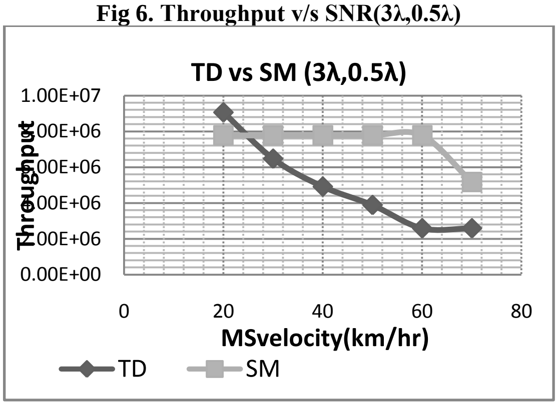

Fig 7. Throughput v/s MSvelocity (3λ,0.5λ)

3.4 For BS Spacing 2λ and MS 0.4λ

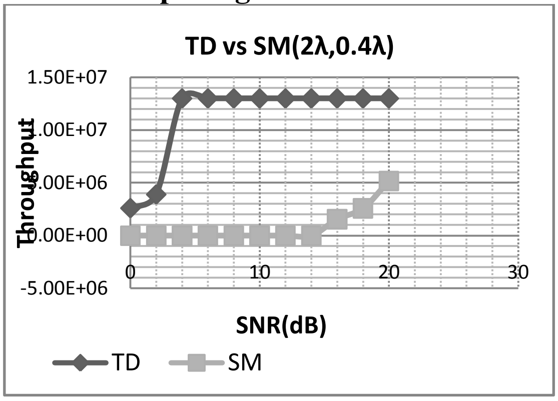

Fig 8. Throughput v/s SNR(2λ,0.4λ)

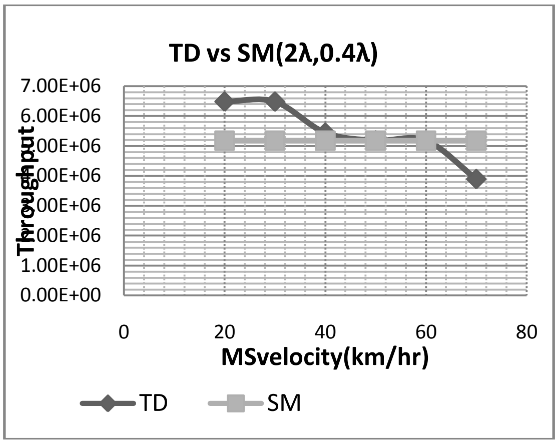

Fig 9. Throughput v/s MSvelocity (2λ,0.4λ)

From the comparative figures for TD vs SM shown above it is observed that Transmit Diversity mode of 2x2 MIMO system attains 100% of throughput value at low (4dB) SNR while Spatial Multiplexing requires a high SNR range >20dB to attain 100% throughput fraction. MSvelocity have shown a significant effect in TD mode compare to SM. From the figures shown above it is revealed that the throughput decreases with increase in MSvelocity from 20 to 70 km/hr in TD while it remains almost constant in SM and also it is noticed that the moderate value of throughput is achieved between 20-50km/hr in both the cases.

We can therefore conclude that with increasing SNR throughput fraction increases in both the TD and SM modes but the SM is a better choice for high rate systems operating at relatively high SNRs while TD is more appropriate for transmitting at relatively low rates and low SNRs. Also it is concluded that antenna to antenna spacing among base station and mobile station antennas have an very effective role with varying SNR range as well as MSvelocity. A comparative study of TD and SM modes for optimizing antenna spacing at BS ans MS have been shown above. It is concluded from that as the SNR conditions improves to medium range (6 to 10dB) throughput increases for the system with larger MS antenna spacing however it remains negligible for antenna with low BS spacing. Hence , in indoor moderate scattered environment (typical office), for lower SNR range the mobile station may select antenna spacing between 0.5λ to 1λ or 1.25λ and BS may use antenna at 2λ or more spacing. However, for higher SNR range MS should be kept at 1λ with BS at 2λ or 3λ or more spacing.

4. CONCLUSION

From the comparative study of TD and SM mode of 2x2 MIMO system using Correlation Channel Model we have determined that SM is the better choice for high rate systems operating at relatively high SNRs while TD is more appropriate for transmitting at relatively low rates and low SNRs. Therefore we can switch between SM and TD according to channel state. The SM is typically well suited to users with good channel conditions that is, to users near the cell center with a high signal-to-noise ratio (SNR). The TD is best suited for users with bad channel conditions that is, to users near the cell edge with a low SNR.

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