Modelling, Simulation and Capacity Analysis of Spatial Channel Models in MIMO System

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Abstract

Future wireless communication systems will utilize the spatial properties of the wireless channel to improve the spectral efficiency and thus increase capacity. This is realized by deploying multiple antennas at both the transmitter and receiver. Due to the unpredictable nature of the wireless channel, a common approach is to model its effects statistically. A few large world-wide co operations, like the third generation partnership project (3GPP) have developed channel models intended for reference and standardization use. These models are partly based on some bulk parameters that describe the characteristics of the channel over larger areas of several wavelengths. Such parameters include shadow fading, angle spread, and delay spread, etc. In the spatial channel model (SCM) these large-scale parameters are assumed independently between separate links, i.e., channel modelling, propagation between different mobile and base stations. This paper focuses on investigation of MIMO system capacity using the Spatial Channel Model (SCM) and Channel Capacity, Spatial Autocorrelation for different channel environments, proposed by standardization bodies (3GPP-3GPP2) for third generation systems. This SCM offers three environments such as suburban macro-cell, urban macro-cell and urban micro-cell parameters are obtained by using MATLAB 7.12.0.
Keywords- SCM, AMPS, FDMA, GPRS

I. INTRODUCTION

Wireless communication system is the fastest growing segment of the communications industry. As such, it has captured the attention of the media and the imagination of the public. The vision of wireless communications supporting information exchange between people or devices is the communications frontier of the next few decades, and much of it already exists in some form. Wireless networks will connect palmtop, laptop, and desktop computers anywhere within an office building or campus, as well as from the corner cafe. Wireless systems continue to starving for ever higher data rates as it go on changing from one generation to another. This goal is particularly challenging for systems that are power, bandwidth, and complexity limited. However, another domain can be exploited to significantly increase channel capacity, this can be achieved by using multiple transmit and receive antennas at the transmitting and receiving section. A solution to this capacity problem emerged during the 50's and 60's when researchers at AT&T Bell Laboratories developed the cellular concept [1].The first generation (1G) cellular systems in the U.S called the Advance Mobile Phone Service (AMPS), used FDMA only for transmitting voice channels. A similar system, the European Total Access Communication System (ETACS), emerged in Europe was deployed worldwide in the 1980's. These European 1G systems are incompatible; therefore 2G came into existence. The 2G digital system is called as GSM; this system is a combination of TDMA and slow frequency hopping with frequency-shift keying for the voice modulation. These are used to support high rate packet data services; feature of this generation is SMS, Call waiting etc. GSM (Global system for mobile communication) systems provide data rates of up to 100 Kbps by aggregating all time slots together for a single user. This enhancement is called GPRS. The combination of these GSM/GPRS gives the existence of 2.5G used at 1800 MHz can be used to access internet. The third generation (3G) cellular systems are based on a wideband CDMA standard developed within the auspices of the International Telecommunications Union (ITU). In the 3rd generation (3G) and beyond-3G (B3G) wireless communication system, high data rate transmission and better quality of service are demanded. This motivates the investigation towards the full exploitation of time, frequency and more recently space domains.

II. BACKGROUND TECHNOLOGIES

Bell laboratory was the first to demonstrate a laboratory prototype of spatial multiplexing in 1998, where spatial multiplexing is a principal technology to improve the performance of MIMO communication systems.

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A. Functions of MIMO

MIMO can be sub-divided into three main categories, precoding, spatial multiplexing or SM and diversity coding.

1) Precoding

Precoding is multi-stream beam forming, in the narrowest definition. In more general terms, it is considered to be all spatial processing that occurs at the transmitter. In (single-layer) beam forming, the same signal is emitted from each of the transmit antennas with appropriate phase (and sometimes gain) weighting such that the signal power is maximized at the receiver input. The benefits of beam forming are to increase the received signal gain, by making signals emitted from different antennas add up constructively, and to reduce the multipath fading effect. In the absence of scattering, beam forming results in a well-defined directional pattern, but in typical cellular conventional beams are not a good analogy. When the receiver has multiple antennas, the transmit beam forming cannot simultaneously maximize the signal level at all of the receive antennas, and precoding with multiple streams is used. Precoding requires knowledge of channel state information (CSI) at the transmitter.

2) Spatial Multiplexing

Spatial multiplexing requires MIMO antenna configuration. In spatial multiplexing, a high rate signal is split into multiple lower rate streams and each stream is transmitted from a different transmit antenna in the same frequency channel. If these signals arrive at the receiver antenna array with sufficiently different spatial signatures, the receiver can separate these streams into (almost) parallel channels. Spatial multiplexing is a very powerful technique for increasing channel capacity at higher signal-to-noise ratios (SNR). The maximum number of spatial streams is limited by the lesser in the number of antennas at the transmitter or receiver. Spatial multiplexing can be used with or without transmit channel knowledge. Spatial multiplexing can also be used for simultaneous transmission to multiple receivers, known as space-division multiple accesses. By scheduling receivers with different spatial signatures, good separability can be assured.

3) Spatial Diversity

Spatial Diversity techniques are used when there was no channel knowledge at the transmitter. In diversity methods, a single stream (unlike multiple streams in spatial multiplexing) is transmitted, but the signal is coded using techniques called space-time coding. The signal is emitted from each of the transmit antennas with full or near orthogonal coding. Diversity coding exploits the independent fading in the multiple antenna links to enhance signal diversity. Because there is no channel knowledge, there is no beam forming or array gain from diversity coding.

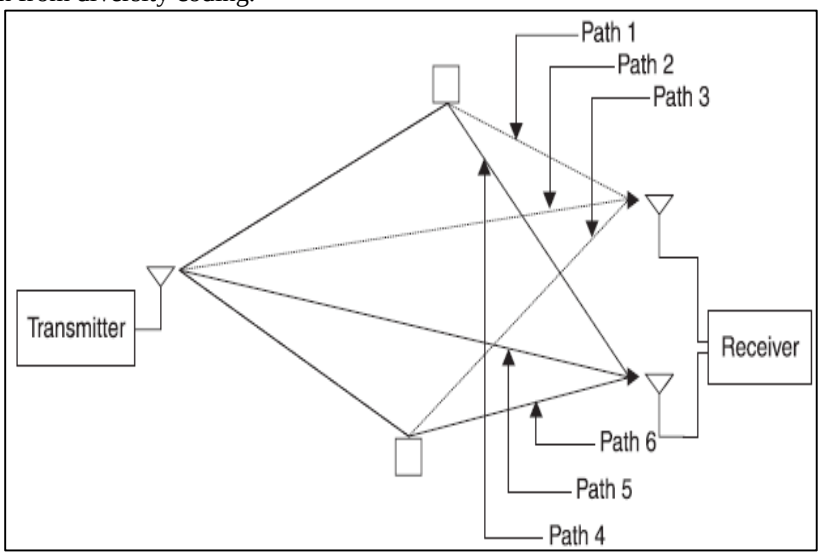

Fig. 2.1: Example of a 1 x 2 receive-diversity system

In some cases, the multiple signals add destructively at the receiver, creating points in space where the composite received signal is greatly attenuated. This is referred to as multipath interference. To combat the effects of multipath interference, we can employ an array of antennas at the receiver, with each antenna separated by some distance in space. This is illustrated in Figure 2.1 for the case where the receiver employs a two-element antenna array.

III. RESULTS

A. Suburban Macro Cell

In this section we present some stimulate results for Channel capacity and Spatial Autocorrelation in Suburban macro-cell environment.

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1) Channel Capacity

The Figure 3.1 and Figure 3.2 show the simulated channel capacity for 3 sector antennas and 6 sector antennas respectively at base station in Suburban macro-cell environment and how the channel capacity varies with time. Here the red trace indicates the average channel capacity and blue trace indicates the random channel capacity.

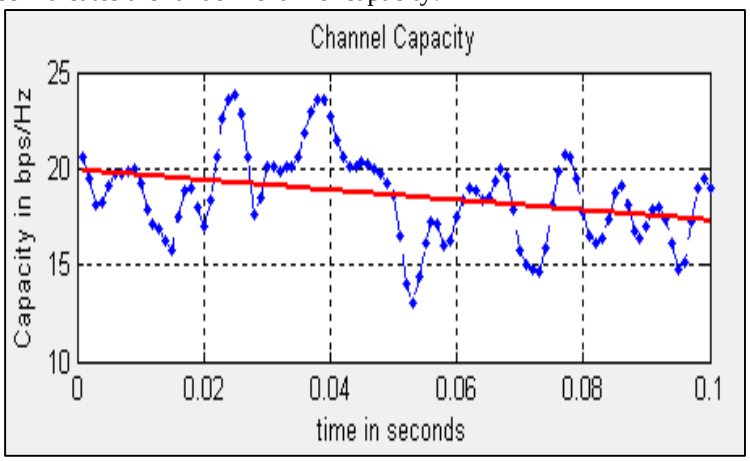

Fig. 3.1: Channel capacity for 3 sector antenna

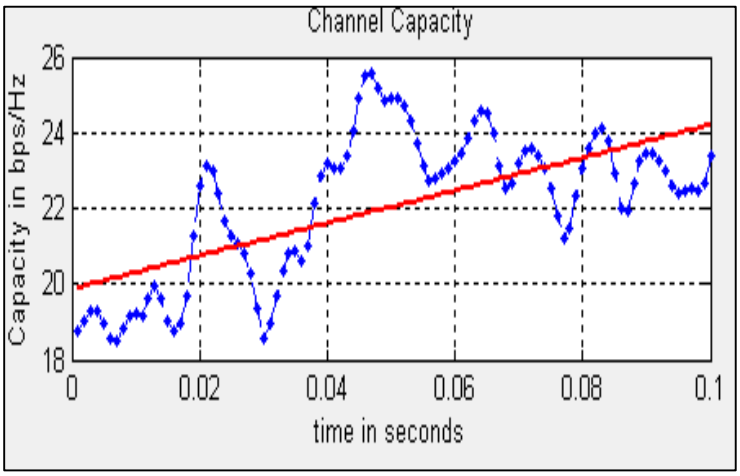

Fig. 3.2: Channel capacity for 6 sector antenna

B. Urban Macro Cell

In this section we present some stimulate results for Channel capacity and Spatial Autocorrelation in Urban macro-cell environment.

1) Channel Capacity

The Figure 5.5 and Figure 5.6 gives the channel capacity for 3 sector antennas and 6 sector antennas respectively at base station in Urban macro-cell environment and how the channel capacity varies with time.

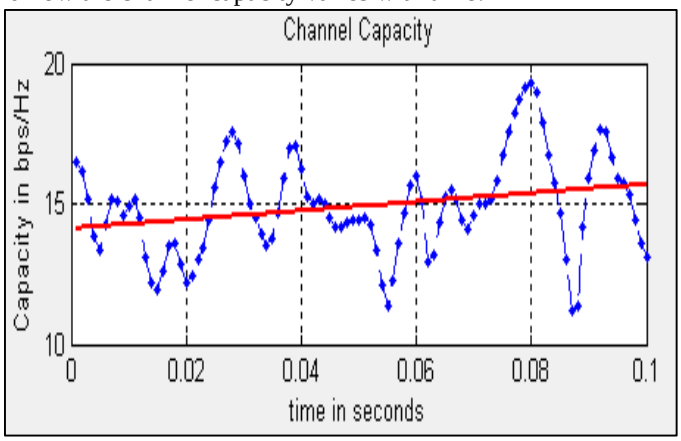

Fig. 3.3: Channel capacity for 6 sector antenna

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C. Urban Micro Cell

In this section we present some stimulate results for Channel capacity and Spatial Autocorrelation in Urban micro-cell environment.

1) Channel Capacity

The Figure 5.9 and Figure 5.10 gives the channel capacity for 3 sector antennas and 6 sector antennas respectively at base station in Urban micro-cell environment and how the channel capacity varies with time.

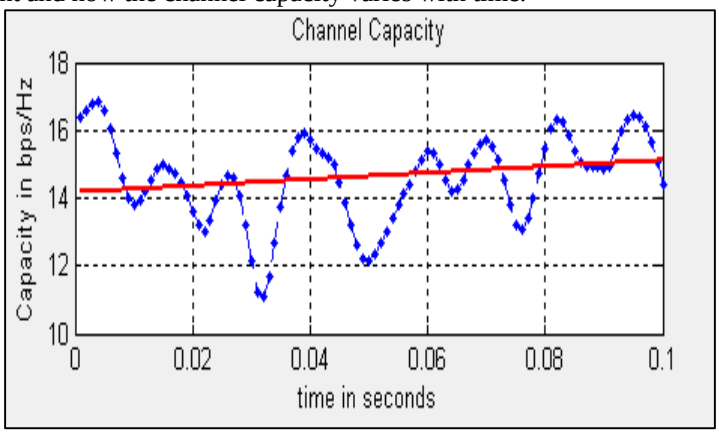

Fig. 3.4: Channel capacity for 3 sector antenna

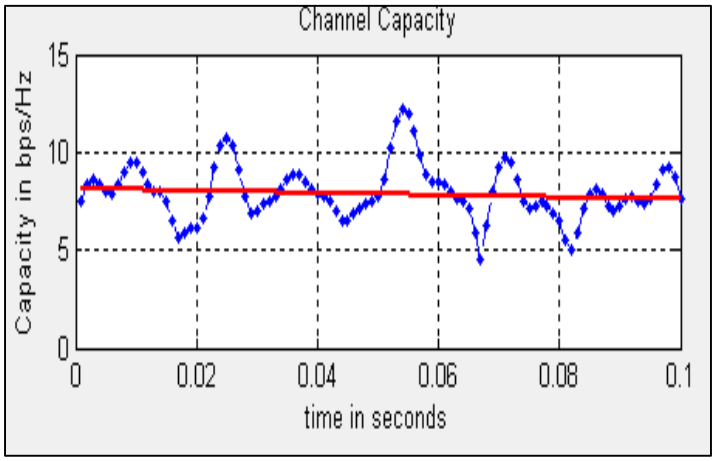

Fig. 3.5: Channel capacity for 6 sector antenna

IV. CONCLUSION AND FUTURE SCOPE

The spatial channel model proposed by the Third Generation Partnership Project (3GPP) has been studied by numerical simulations. It was found out that the 3GPP SCM model tends to estimate the MIMO outage channel capacity in three environments. This is due to the static nature of the 3GPP SCM in which each signal path is modeled by 20 sub paths having fixed azimuth directions and fixed power levels. The capacity of the suburban macro-cell in 6-sector case was found to be higher than other cases. This is because the increased angle spread in the suburban macro-cell reduces correlation and increases capacity taking the considerations of antenna number. From the results we can clearly see that channel which gives the high Autocorrelation gives less capacity. Thus, the model is characterized by relatively small spatial correlation between MIMO antennas.

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