MIMO PERFORMANCE EVALUATION BASED ON VARIOUS SCENARIOS

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This Report Presented in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science in Electronics and Telecommunication Engineering

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APPROVAL

This Project titled **"MIMO Performance Evaluation Based On Various Scenarios**", submitted by Plaban Mondal, Md. Anik Arefin Nahin and Humayun Kabir Shabuj to the Department of Electronics and Telecommunication Engineering, Daffodil International University, has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of B.Sc. in Electronics and Telecommunication Engineering and approved as to its style and contents. The presentation has been held on 27-08-2012.

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DECLARATION

We hereby declare that, this project has been done by us under the supervision of Md. Mirza Golam Rashed Assistant Professor Department of ETE Daffodil International University. We also declare that neither this project nor any part of this project has been submitted elsewhere for award of any degree or diploma.

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ABSTRACT

MIMO is one of several forms of smart antenna technology in which multiple antennas are used at both the source or transmitter and the destination or receiver.

In conventional wireless communications, a single antenna is used at the source, and another single antenna is used at the destination. In some cases, this gives rise to problems with multipath effects. The use of two or more antennas, along with the transmission of multiple signals, one for each antenna, at the source and the destination, eliminates the trouble caused by multipath wave propagation, and can even take advantage of this effect. This report provides an analysis of MIMO channel capacity in terms of different condition of MIMO antenna using MATLAB simulation software. It also shows a comparison between MIMO channel capacity and theoretical Shanon's channel capacity. Another comparison is also shown between SISO and MIMO with the help of real world data. The comparisons are conducted using the parameters RSSI, Jitter, Power Level, Bandwidth, BER and FER for different types of modulation schemes and fading channels.

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CHEAPTER 1: INTRODUCTION

1.1 Motivation

With the proceeding time technology is growing higher. All the new inventions are busy to reduce human effort. People are taking how to get more comfortable. To become more comfortable people started thinking about wireless technology. With this everyone can be more comfortable and more mobile. Behind the thought of wireless the most important thing is antenna i.e. a transducer.

After invention of antenna technology has to improve its performances day by day. From this thought different type of antenna has been invented. Our invention is to choose the write antenna system according to their performance, So that we can more comfortable and mobile.

1.2 History

The history of wireless networks and of wireless networking goes hand in hand. Without the discovery of technology such as the radio, wireless technology would not exist at all today. The history of wireless networking goes as far back as the 1800's with the advent of radio waves. The advent of more technology grew throughout the years and expanded to what we communicated with today [1].

In 1888, a Hamburg, Germany born physicist named Heinrich Rudolf Hertz produced his first radio wave ever. By 1894 this radio wave production became a way of communication. Telegraph wires were used to receive the radio waves in signal form. Hertz opened the way for radio, television, and radar with his discovery of electromagnetic waves. An Italian inventor named MarcheseGuglielmo Marconi then expanded the radius of radio wave sending to two miles, becoming the "father of the radio." By 1899, this form of telecommunication could travel pretty far for its time. Marconi could send a signal 9 miles across the Bristol Channel. He eventually expanded the radius to 31 miles across the English Channel to France. By 1901 the communication area became immense. Marconi could send signals across the entire Atlantic Ocean [1] [2].

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1.3 How Wireless Work

A wireless network begins with the sending and receiving of data. Any data that our computer or any other device intends to share over a network is first sent to the network's wireless adapter. This information can be anything from sending and receiving large files to simple text instant messages from one computer to another [1].

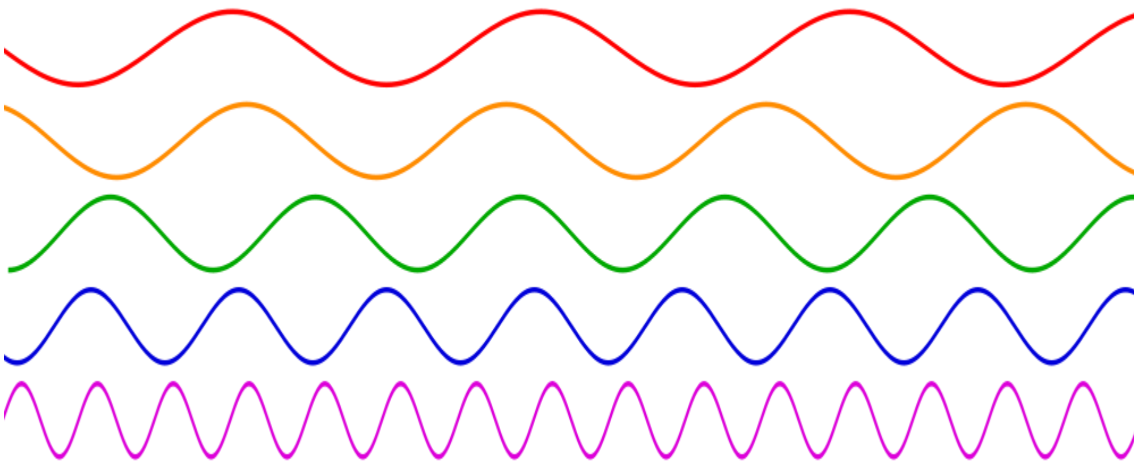

Figure 1.1: Electromagnetic Wave.

The adapter translates this information into a radio signal and then sends over an antenna. Then the antenna sends the signal directly to the air in a special format which is commonly known as Electromagnetic Wave. The other antenna receives the radio signal and converts it back into a format that device that we are using can understand. Once this has happened, the information can be accessed by all computers or other devices on the network if made accessible to everyone, or just to individual devices if the specification was made [2].

1.4 Problem on Wireless Network

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As we know in wireless network antennas directly sends the Electromagnetic wave to the air, the free space is not fully free at all. There is a lot of thing in the space, with which the EMW collide and loses its strength. Signals get distorted and attenuated. This phenomenon is known as fading.

The presence of reflectors in the environment surrounding a transmitter and receiver create multiple paths that a transmitted signal can traverse. As a result, the receiver sees the superposition of multiple copies of the transmitted signal, each traversing a different path. Each signal copy will experience differences in attenuation, delay and phase shift while travelling from the source to the receiver. This can result in either constructive or destructive interference, amplifying or attenuating the signal power seen at the receiver. Strong destructive interference is frequently referred to as a deep fade and may result in temporary failure of communication due to a severe drop in the channel signal-to-noise ratio [2].

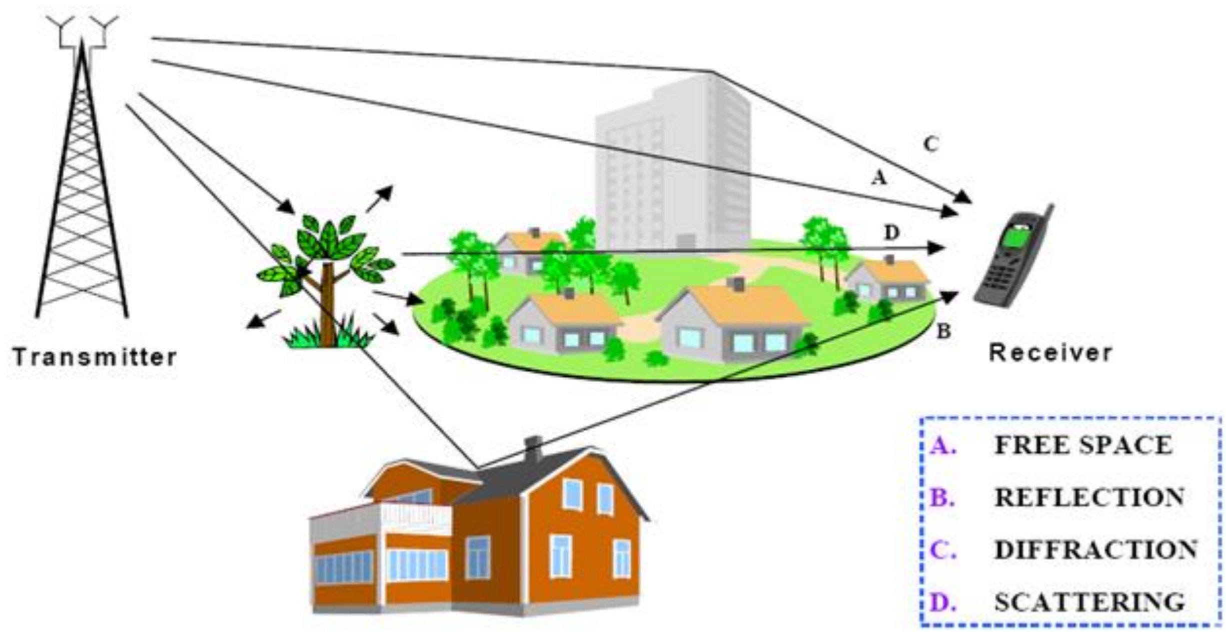

Figure 1.2: Wireless fading for building.

A common example of multipath fading is the experience of stopping at a traffic light and hearing an FM broadcast degenerate into static, while the signal is re-acquired if the vehicle moves only a fraction of a meter. The loss of the broadcast is caused by the vehicle stopping at a point where the signal experienced severe destructive interference. Cellular phones can also exhibit similar momentary fades.

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Fading channel models are often used to model the effects of electromagnetic transmission of information over the air in cellular networks and broadcast communication. Fading channel models are also used in underwater acoustic communications to model the distortion caused by the water. Mathematically, fading is usually modeled as a time-varying random change in the amplitude and phase of the transmitted signal [2] [3].

1.5 How to Overcome

To overcome this problem the concept of Smart antenna has been introduced. A smart antenna is a digital wireless communications antenna system that takes advantage of diversity effect at the source (transmitter), the destination (receiver), or both. Diversity effect involves the transmission and/or reception of multiple radio frequency (RF) waves to increase data speed and reduce the error rate.

Figure: 1.3: Smart Antennas

In conventional wireless communications, a single antenna is used at the source, and another single antenna is used at the destination. This is called SISO (single input, single output). Such systems are vulnerable to problems caused by multipath effects. When an electromagnetic field (EM field) is met with obstructions such as hills, canyons, buildings, and utility wires, the wave fronts are scattered, and thus they take many paths to reach the destination. The late arrival of

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scattered portions of the signal causes problems such as fading, cut-out (cliff effect), and intermittent reception (picket fencing). In a digital communications system like the Internet, it can cause a reduction in data speed and an increase in the number of errors. The use of smart antennas can reduce or eliminate the trouble caused by multipath wave propagation.

Smart antennas fall into three major categories: SIMO (single input, multiple output), MISO (multiple input, single output), and MIMO (multiple input, multiple output). In SIMO technology, one antenna is used at the source, and two or more antennas are used at the destination. In MISO technology, two or more antennas are used at the source, and one antenna is used at the destination. In MIMO technology, multiple antennas are employed at both the source and the destination. MIMO has attracted the most attention recently because it cannot only eliminate the adverse effects of multipath propagation, but in some cases can turn it into an advantage [4][5].

To exploit the benefits the virtual wires offer, MIMO uses multiple, spatially separated antennas. MIMO encodes a high-speed data stream across multiple antennas. Each antenna carries a separate, lower-speed stream. Multipath virtual wires are utilized to send the lower-speed streams simultaneously.

However, wireless is not as well behaved as a bundle of wires. Each signal transmitted in a multipath environment travels multiple routes. This makes a wireless system act like a bundle of wires with a great deal of leakage between them, causing transmitted signals to jumble together. The MIMO receiver uses mathematical algorithms to unravel and recover the transmitted signals [5].

CHEAPTER 2: SMART ANTENNA SYSTEM

2.1 Antenna & Smart Antenna

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An antenna is a specialized transducer that converts radio-frequency (RF) fields into alternating current (AC) or vice-versa. There are two basic types: the receiving antenna, which intercepts RF energy and delivers AC to electronic equipment, and the transmitting antenna, which is fed with AC from electronic equipment and generates an RF field.

Physically, an antenna is an arrangement of one or more conductors, usually called elements in this context. In transmission, an alternating current is created in the elements by applying a voltage at the antenna terminals, causing the elements to radiate an electromagnetic field. In reception, the inverse occurs: an electromagnetic field from another source induces an alternating current in the elements and a corresponding voltage at the antenna's terminals. Some receiving antennas (such as parabolic and horn types) incorporate shaped reflective surfaces to collect EM waves from free space and direct or focus them onto the actual conductive elements.

A smart antenna is a digital wireless communications antenna system that takes advantage of diversity effect at the source (transmitter), the destination (receiver), or both. Diversity effect involves the transmission and/or reception of multiple radio frequency (RF) waves to increase data speed and reduce the error rate.

Smart antennas have promised to provide significant increases in system capacity and performance in wireless communication systems [6]. In turn, this leads to increased revenue for the telecommunications companies and also a reduction in dropped and blocked calls. Other benefits include greater coverage, meaning less base stations are needed to cover the same area compared to conventional antennas. For these reasons, smart antennas have gained greater interest over the recent years [5][6].

2.2 Why Smart Antenna

- Due to the targeted nature of smart antennas frequencies can be reused allowing an increased number of users.
- As the smart antenna focuses gain on the communicating device, the range of operation increases.

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- Flexible antenna configuration for different site conditions such as rooftop or towers.
- Smart antennas naturally provide increased security, as the signals are not radiated in all directions as in a traditional Omni-directional antenna.
- Interference which is usually caused by transmissions which radiate in all directions is less likely to occur due to the directionality introduced by the smart antenna.
- The bandwidth available increases form the reuse of frequencies.
- Smart antennas are not a new protocol or standard so the antennas can be easily implemented with existing non smart antennas and devices.
- Wi-Fi outdoor base station optimized for maximum coverage with minimal installation sites
- Multiple-radio smart antenna platform supports 360-degree coverage
- Support standard 802.11b/g/n access and 802.11a backhaul radius [4].

2.3 Execution technique of a Smart Antenna System

The wireless spectrum is limited and during the last decade it has become a precious resource. Achieving the capacities needed for future wireless systems without increasing the required spectrum will only be accomplished by the design and implementation of advanced communications techniques such as multi-antenna systems. These systems are realized by time-consuming and computationally complex algorithms [4].

2.4 Smart Antenna Network Architecture

Wireless solution by this type of smart antenna is one type of cellular architecture like. The main antenna will be situated in a top building. The antenna is attached with another Line Of Sight trans-receiver by which it can communicate with AP or another Antenna.

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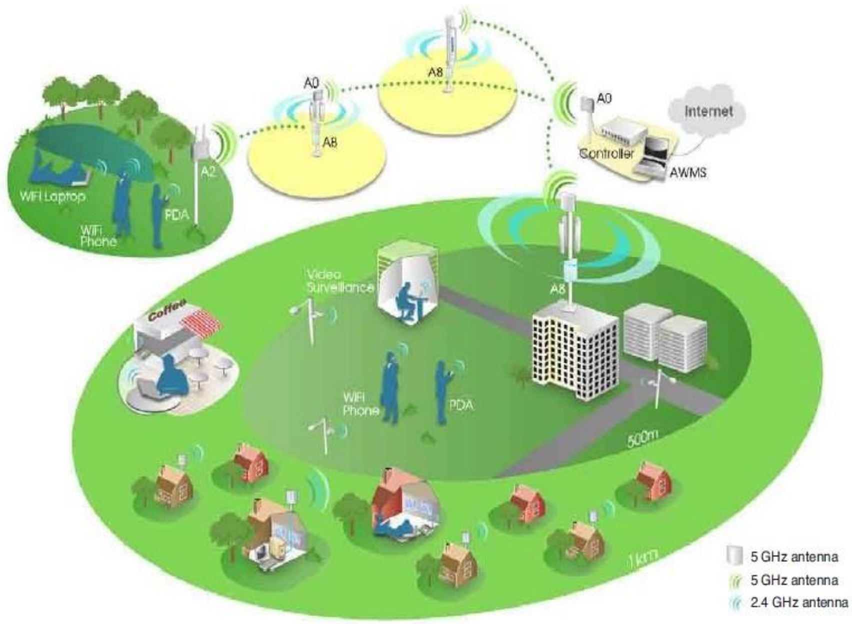

Figure: 2.1: Smart Antenna Network Architecture.

2.4.1 Single (Mega) Cell

In mega cell architecture, a large service area with a radius of up to 30 miles is covered by one or two cells. The base station antenna is typically located on a very high tower or hill top (height of 500 to 1200 ft.) to provide line of sight (LOS) paths to subscribers. A high gain CPE rooftop mounted antenna pointing towards the base station is used. Frequency reuse in angle (and polarization) may be possible with sectorization particularly on the uplink. The carrier to noise ratio (C/N) of around 25 to 33 dB needed for high order modulation is sustained by the high antenna gains and low loss line of sight (LOS) propagation. Mega cells are possible only in the microwave bands because there is severe foliage and rain attenuation in the mill metric bands that limit the range considerably [4] [7].

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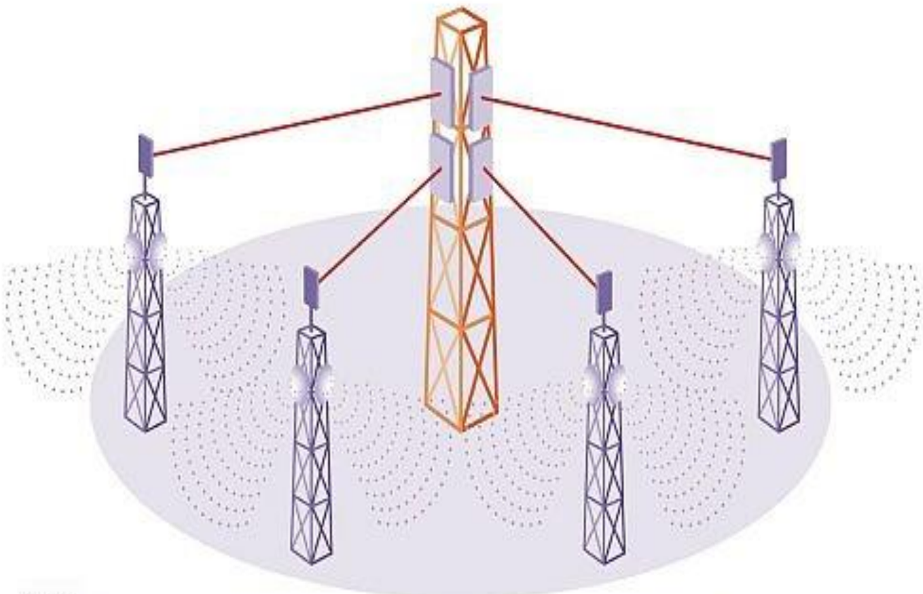

Figure: 2.2: Cellular Architecture for Mega cell.

2.4.2 Macro Cell

Macro cellular systems use spatial frequency reuse to cover the service area. The BTS heights are similar to cellular infrastructure. Macro cells therefore typically use 4 QAM modulations, a spatial reuse factor of 3 to 4 and no angle reuse. LOS propagation is usually not possible, and cell ranges are therefore much smaller (1 – 4 miles) due to

higher path loss[4] [7].

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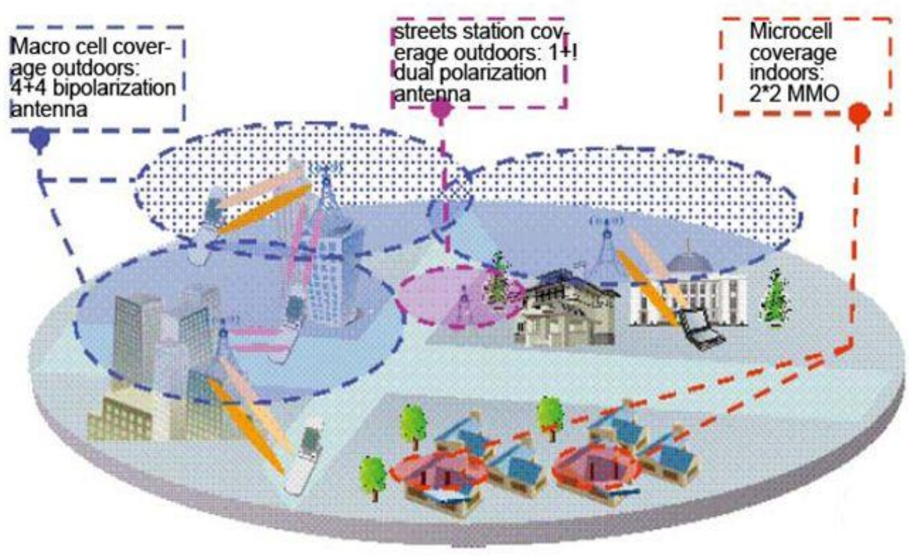

Figure: 2.3: Cellular Architecture for Macro Cell.

The following table compares two different cellular architectures for BWA. In practice, both systems may co-exist in an overlay - underlay deployment scenario

	MEGA-CELL	**MACRO-CELL**
No. of Cells	One	Multiple
BTS Antenna Height	High(>500’)	Low(~100’)
CPE Antenna height	Rooftop (>30’)	Medium(~15’)
Propagation	LOS needed	NLOS acceptable
Frequency Bands	<5 GHz	<5 GHz and mill metric
Reuse	Angle Reuse	Spatial Reuse
Coverage	<30-40 miles	<3-4 miles

Table 2.1: Mega cell vs. Macro cell.

2.5 Function of Smart Antennas

Based on the signal processing technique followed at the baseband output of the antenna array smart antennas can be grouped into four basic types based on:

i) Beam forming

ii) Spatial multiplexing

iii) Diversity combining

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iv) Space time equalization

2.5.1 Beam forming

Smart antenna technology offers a significantly improved solution to reduce interference levels and improve the system capacity. With this technology, each user's signal is transmitted and received by the base station only in the direction of that particular user. This drastically reduces the overall interference in the system. A smart antenna system consists of an array of antennas that together direct different transmission/reception beams toward each user in the system.

Figure: 2.4(a)

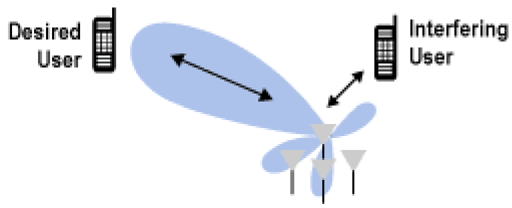

Figure: 2.4(b)

Figure: 2. 4: (a) Smart Antenna System—Beam forming 2.4: (b) User beam forming transmission

This method of transmission and reception is called beam forming and is made possible through smart (advanced) signal processing at the baseband [8].

In beam forming, each user's signal is multiplied with complex weights that adjust the magnitude and phase of the signal to and from each antenna. This causes the output from the array of antennas to form a transmit/receive beam in the desired direction and minimizes the output in other directions.

2.5.2 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

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array with sufficiently different spatial signatures, the receiver can separate these streams, creating parallel channels free. Spatial multiplexing is a very powerful technique for increasing channel capacity at higher Signal to Noise Ratio (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 [8] [9].

2.5.3 Diversity combining

Diversity Coding techniques are used when there is 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 using certain principles of full or near orthogonal coding. Diversity 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 [8].

2.5.4 Space time equalization

The preceding two techniques usually assume that the signal of interest is a narrowband signal compared to the coherence bandwidth of the channel and is thus subjected to flat fading across the bandwidth of the signal. Multipath fading in wireless communication can also introduce frequency distortion to the received signal. By introducing temporal processing in each antenna element to remove the effect of frequency distortion and doing a spatial combining described above results in mitigating channel induced frequency selective fading and providing antenna gain. Such schemes are called space-time adaptive processing (STAP) or equalization [8] [9].

2.6 Smart / Multi-antenna System

A smart antenna is a digital wireless communications antenna system with multiple antenna elements at the source (transmitter), the destination (receiver), or both, where signals from the different antenna elements are combined or created in an intelligent way by an algorithm. The smart antenna system can be utilized in a number of ways. It can be used to increase the capacity and the coverage (beam forming) in a mobile communication system. It can also be used for

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improving the link quality, user position estimation, and to decrease the delay dispersion. There are a few techniques that are used as an approach to this system [3].

The antenna system characterization with respect to the number of antennas used at transmitter and receiver can be described as follows:

- SISO: Single-Input Single-Output
- SIMO: Single-Input Multiple-Output
- MISO: Multiple-Input Single-Output
- MIMO: Multiple-Input Multiple-Output

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CHEAPTER 3: MAJOR TYPES OF SMART ANTENNAS

3.1 SISO: Single-Input Single-Output

Conventional wireless communications, a single antenna is used at the source, and another single antenna is used at the destination as shown in Figure 3.1. This communication system is referred to as a single input - single output (SISO) system.

Assume that a transmitter with a single antenna element transmits Omni directional, meaning that the signal or wave front is transmitted in all directions, and that the receiver antenna listens for signals coming from all directions. Sending signals by transmitting energy in all directions is not energy efficient.

Figure 3.1: A conventional SISO communications system.

In this case transmitter and receiver both have single antenna. The signal is transmitted using single channel. The basic SISO communication system can be described as follows

Figure 3.2: SISO Communication System.

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Here are as shown in figure the channel used has the channel gain h1. This model is the very basic simulation model of communication system. Here we used channel with the gain h1 as follows:

$\boldsymbol{h1} = |\boldsymbol{g}|^2$ Where, **g** is the channel coefficient.

A better way is to only transmit in the direction of the receiver. In the same manner it is more efficient to only listen in the direction of the transmitter and not in all directions at the same time. This will increase energy efficiency and will also lead to a reduction in interference between different transmitters and thereby increase the efficiency in an interference limited system [6][8].

Another drawback with SISO systems is that they are vulnerable to multipath effects. When the electromagnetic wave form travels towards the receiver, its propagation path can be obstructed by object. In an outdoor environment this can for instance be caused by objects such as hills, buildings, trees, cars, etc., while in an indoor scenario the signal can be obstructed by doors, walls, people, furniture, etc. The wave fronts will then be reflected and scattered by these objects, thus creating multiple paths to the receiver (figure 3.3).

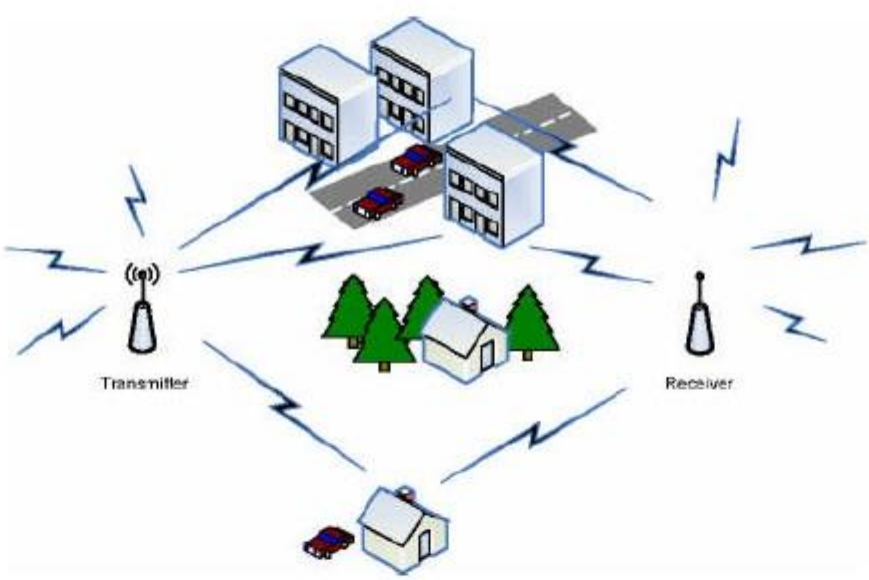

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Figure 3.3: Scattered and reflected signals due to obstruction, causing multipath effects.

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The wave front, arriving in scattered portions at different time instances, can cause problems resulting in intermittent reception [6]. In digital communications this can cause an increase in the number of errors resulting in a reduction in data rate. The use of smart antennas can reduce the deterioration of the transmitted wave front caused by multipath wave propagation by automatically changing the directionality of its radiation patterns in response to its signal environment [8] [9].

3.2 SIMO: Single-Input Multiple-Output

In this case transmitter have single antenna and receiver have multiple antennas. In here we consider two and four antennas at receiver side. The signal is transmitted using single channel. Below figure shows the basic SIMO communication system.

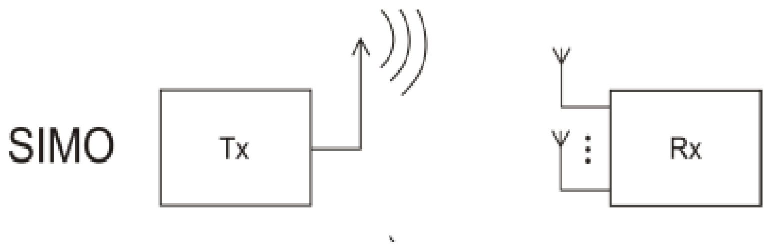

Figure 3.4: SIMO Communication Systems

There are mainly two different categories of smart antenna systems [9]. Single input multiple output system (SIMO). In a SIMO system, one antenna is used at the transmitter, and two or more antennas are used at the receiver as shown in Figure 3.4

Figure 3.5: A single input - multiple output system.

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3.3 MISO: Multiple-Input Single-Output

In this case transmitter has multiple antennas (2 antennas and 4 antennas in our case) and receiver has one antenna. In here we consider two and four antennas at receiver side. The signal is transmitted using single channel. Below figure shows the basic MISO communication system.

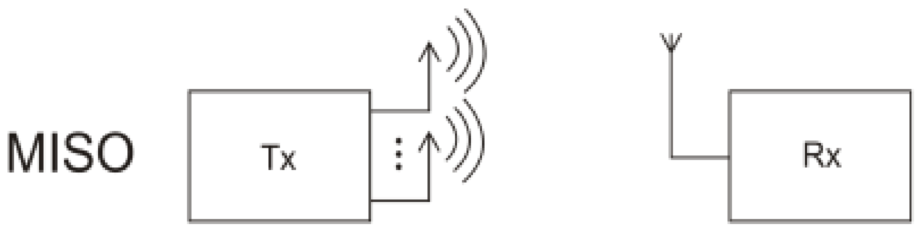

Figure 3.6: MISO Communication Systems

Multiple inputs single output (MISO). In a MISO system, two or more antennas are used at the transmitter, and one antenna is used at the receiver as shown in Figure 3.6.

Figure 3.7: A multiple input - single output system.

By applying the techniques shown in Figures 3.4-3.6 we can transmit in a specific direction or listen in a specific direction. Figure 3.8 shows the same scenario as in figure 3.3 but with a smart antenna as a receiver. The smart antenna system detects the three multi-paths and creates "listening" beams for those directions. Subsequently, all other signals are suppressed [8] [9].

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In this way the signals coming from the directions of the listening beams can be combined at the receiver, thus increasing the signal-to-noise ratio and lowering the bit error rate. The concept of using smart antennas to transmit and receive data more intelligently has existed for many years. Simple smart antenna techniques, like the switched beam technology, where the antenna systems form multiple fixed beams with heightened sensitivity in particular directions, have been used in commercial applications for some time [8] [9]. These antenna systems detect signal strength, choose from one of several predetermined, fixed beams, and switch from one beam to another as the mobile device moves throughout the beam pattern. Smart antenna technology represents the most advanced approach to date taking advantage of its ability to effectively locate and track various types of signals to minimize interference and maximize signal reception [9].

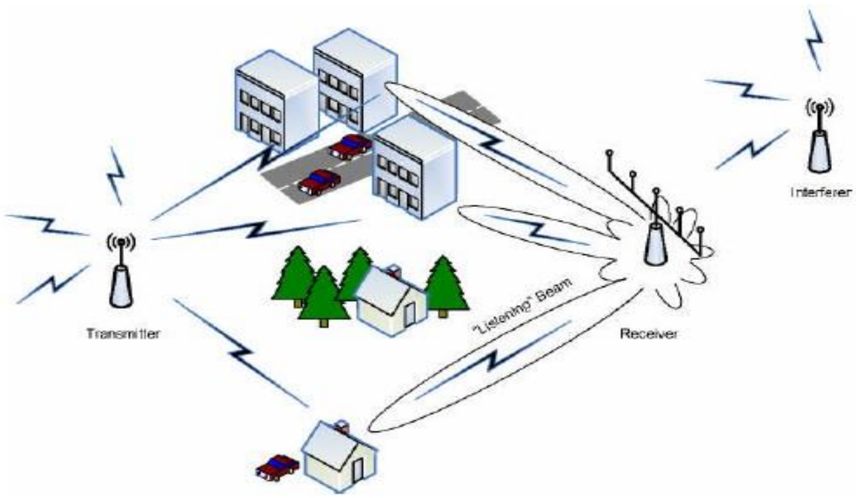

Figure 3.8: A SIMO & MISO system where the multiple antennas at the receiver create beams that listen in the directions of the multipath.

One sophisticated utilization of smart antenna technology is spatial division multiple access (SDMA) [3], [8]. In this technique, single mobile terminals are located and tracked by adaptively steering transmission signals toward users and away from interferers (figure 3.8). In this way a high level of interference suppression is achieved, making possible more efficient reuse of the frequency spectrum.

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Smart antenna technology can, with some modification, be integrated into all major access methods such as frequency division multiple access (FDMA), time division multiple access (TDMA), code division multiple access (CDMA), etc. and has widespread applications in several different areas such as digital television (DTV), body area networks (BAN), personal area networks (PAN), wireless local area networks (WLAN), metropolitan area networks (MAN), and mobile communications [8],[9]. However, the technique requires sophisticated algorithms and computationally heavy algorithms to operate in real-time.

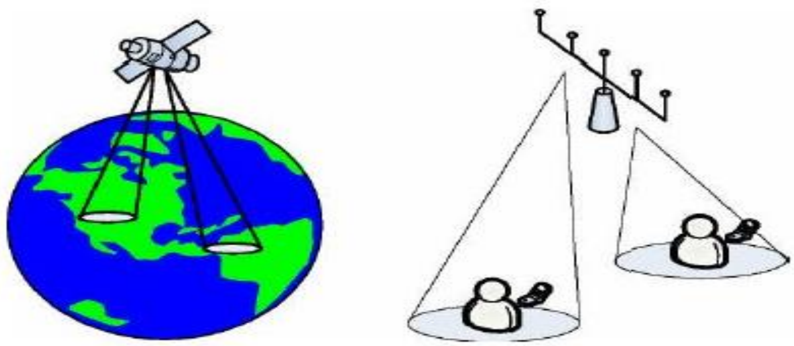

Figure 3.9: Smart antenna techniques can be used in satellite transmission to cover small hotspots, or in cellular systems to track individual mobiles.

3.4 MIMO: Multiple-Input Multiple-Output

In this case transmitter and receiver both have multiple antennas (2 antennas and 4 antennas in our case). In here we consider two and four antennas at receiver side. The signal is transmitted using single channel. Below figure shows the basic MIMO communication system.

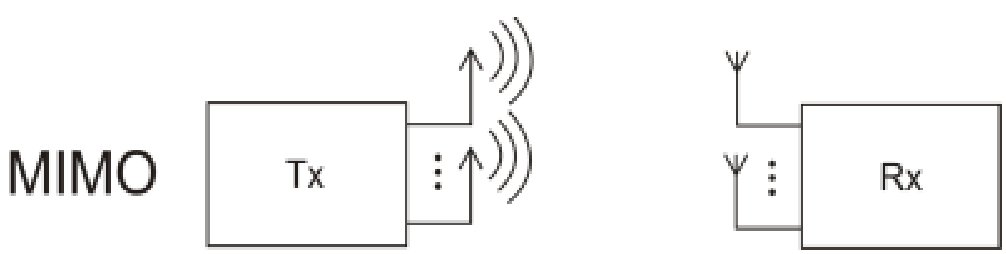

Figure 3.10: MIMO Communication Systems.

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MIMO systems are characterized by having multiple antennas at both the transmitter and the receiver as shown in figure 3.10. The number of antenna elements does not have to be the same at the transmitter and the receiver.

Figure 3.11: A multiple input - multiple output system.

A MIMO system is mainly used for three different purposes; beam forming, diversity, and spatial multiplexing. Both beam forming and diversity can be used in the same way as in the case of the smart antenna system [8]. By applying a MIMO beam forming system to the scenario in figure 3.3, the signal can be transmitted in one or more favorable directions. Figure 3.11 shows how the signal is transmitted in two beams from the transmitter and received via two beams formed by the receiver antenna.

In this way transmission energy is saved, since less energy is transmitted in other directions than those of the receiver. Another way of using a MIMO system that has attracted lots of interest in recent years is spatial multiplexing [10] [11]. Spatial multiplexing offers an improvement of the capacity by simultaneously transmitting multiple data-streams.

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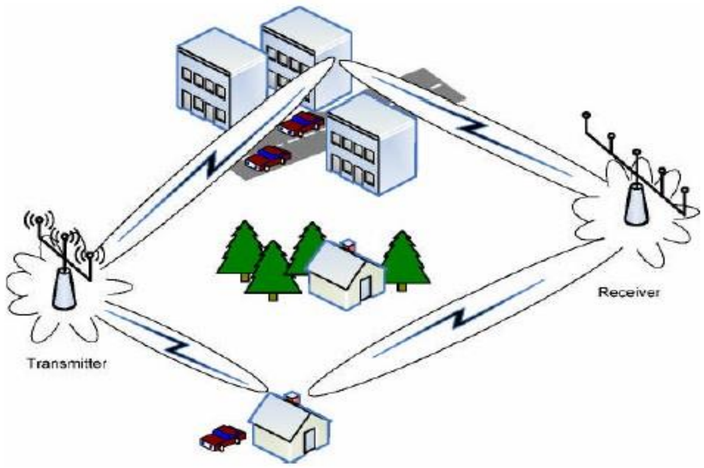

Figure3.12: A MIMO system using beam forming to transmit the signal in specific directions and creating beams to listen for signals coming from those directions.

This is done by multiplexing a data-stream into several parallel data-streams that are sent from separate antenna elements as shown in figure 3.12 [10].

Data transmitted from the multiple antenna elements will be mixed when traveling throughout the propagation channel. Each individual antenna element in the receiver will detect a combination of the transmitted data.

Multiple input multiple outputs (MIMO) is a smart antenna technique that increases speed, range, reliability and spectral efficiency for wireless systems. Given the demands that applications are placing on WLANs, MIMO chipsets will figure prominently in new access points and network interface cards.

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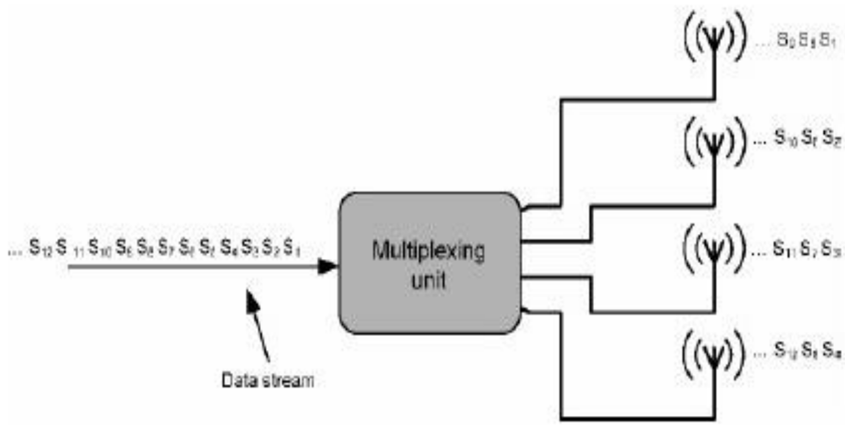

Figure 3.13: A data-stream is multiplexed onto different antenna elements in a MIMO System.

MIMO is one technology being considered for 802.11n, a standard for next-generation 802.11 that boosts throughput to 100M bit/sec. In the meantime, proprietary MIMO technology improves performance of existing 802.11a/b/g networks.

A conventional radio uses one antenna to transmit a data stream. A typical smart antenna radio, on the other hand, uses multiple antennas. This design helps combat distortion and interference. Examples of multiple-antenna techniques include switched antenna diversity selection, radio-frequency beam forming, digital beam forming and adaptive diversity combining.

These smart antenna techniques are one-dimensional, whereas MIMO is multi-dimensional. It builds on one-dimensional smart antenna technology by simultaneously transmitting multiple data streams through the same channel, which increases wireless capacity.

During the 1990s, Stanford University researchers Greg Raleigh and VK Jones showed that a characteristic of radio transmission called multipath, which had previously been considered an impairment to radio transmission, is actually a gift of nature. Multipath occurs when signals sent from a transmitter reflect off objects in the environment and take multiple paths to the receiver. The researchers showed that multipath can be exploited to multiplicatively increase the capacity of a radio system [12].

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If each multipath route could be treated as a separate channel, it would be as if each route were a separate virtual wire. A channel with multipath then would be like a bundle of virtual wires. To exploit the benefits the virtual wires offer, MIMO uses multiple, spatially separated antennas. MIMO encodes a high-speed data stream across multiple antennas. Each antenna carries a separate, lower-speed stream. Multipath virtual wires are utilized to send the lower-speed streams simultaneously.

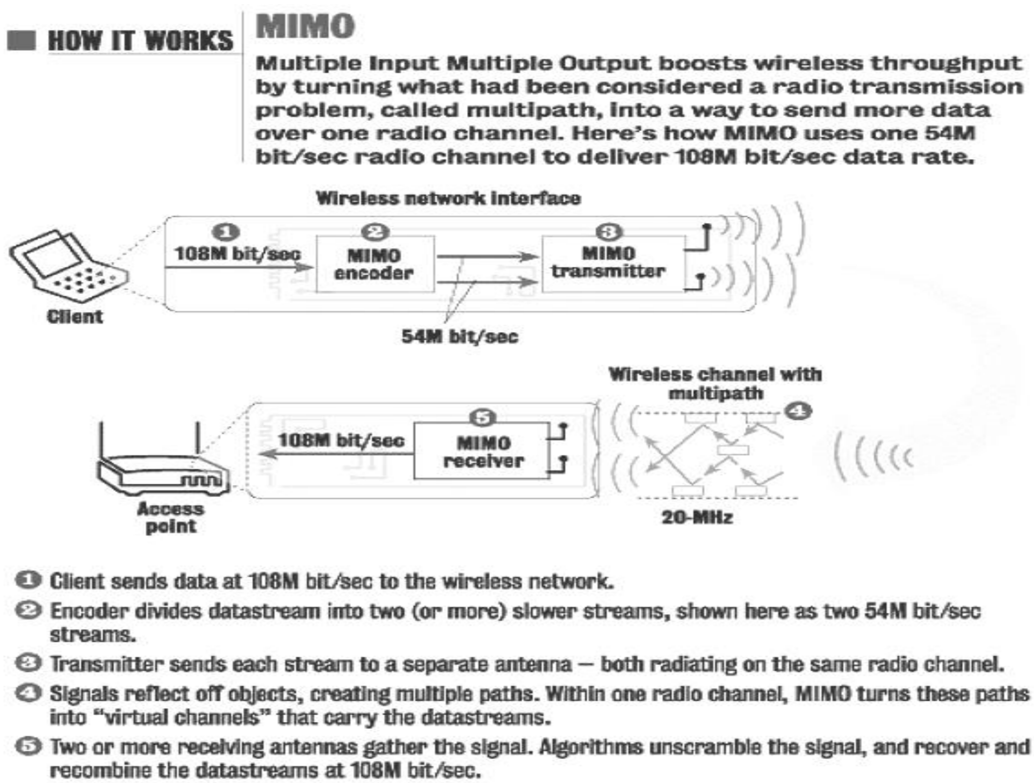

Figure 3.14: MIMO Antenna Work Procedures.

However, wireless is not as well behaved as a bundle of wires. Each signal transmitted in a multipath environment travels multiple routes. This makes a wireless system act like a bundle of wires with a great deal of leakage between them, causing transmitted signals to jumble together. The MIMO receiver uses mathematical algorithms to unravel and recover the transmitted signals [4]

.

The received data must then be resolved by signal processing algorithms before it can be combined into a single data stream again. In this way MIMO can exploit the phenomena of multipath propagation to increase throughput, or reduce bit error rates, rather than suffer from it [11].

MIMO will be incorporated into the new IEEE 802.1 1n standard for local-area wireless networks, which will improve the coverage and data rate significantly. The IEEE 802.1 1n standard is still being discussed, but data throughput is estimated to reach a theoretical 540 Mbit/s. The data rate requirement at the physical layer may be even higher, prompting for new high-speed hardware solutions. Although a few manufacturers have released consumer products with so called pre-n hardware, exploiting rudimentary diversity by using 2 to 4 antenna elements, the widespread usage of MIMO will not be a reality before the standard is set. MIMO has also been added to the latest draft version of Mobile Wimax (IEEE 802.16e).

To be able to fully take advantage of the emerging standards, new high throughput hardware architectures must be developed. A first step in the development process is to analyze the multi-antenna algorithms and to identify common algorithmic features [14].

3.5 MIMO Channel Modeling

The most commonly used MIMO channel model assumes the independent identically distributed zero-mean circularly symmetric complex Gaussian random variable with unity variance as elements of the channel transfer matrix H. Practical channels may in practice deviate from this idealized case, due to e.g. spatially correlated fading or presence of a LOS component leading to Rician fading.

Generally, there are two approaches in channel modeling: antenna specific and antenna generic. In the first one, besides propagation characteristics, the antenna geometry is also included in the model, whereas the other channel model can be used with an arbitrary antenna configuration.

Other classification recognizes deterministic and stochastic channel models. Deterministic channel models are either ray tracing based, or are a collection of recorded impulse responses. Stochastic models can be geometrically based, parametric, or correlation based.

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In geometrically based models, the received signal is calculated based on the positions of the scatters that are located at some (model dependent) positions in the vicinity of the transmitter and receiver, e.g. geometrically based circular model [Ertel et al., 1998]. Parametric stochastic Channel models are site generic channel models, such as IEEE 802.11n [IEEE, 2004b], 3GPP Spatial Channel Model (SCM) [3GPP, 2007] and COST 273 MIMO channel model 1. The resulting channel in different scenarios is obtained by summing up individual paths and their sub paths. The relevant parameters include angle spread at transmitting and receiving station and power-delay distribution. The parameters take different values depending on the scenario and the type of station (base or mobile station), i.e. its location [15].

Correlation based models are not physical models; they imply that the elements of H are correlated. That can be mathematically described by the following equation:

vec(H) = R1⁄2vec(H*w*)…………………..(3a)

Wherever (H) is an operator that stacks the elements of H column wise, and H*w*is spatially white MIMO channel (with independent elements). Matrix RI's the MtMr×MtMrcovariance matrix defined as:

R = E _vec(H)vec(H)H)…………………(3b)

This model can capture any correlation effects between transmitter and receiver. However, due to complexity reasons, Kronecker model is the more often used. Kronecker model assumes separability of transmit and receive antenna correlation:

H = R1/2, r,HwR1/2, t,(3.24)

Where Rris Mr ×Mrreceive correlation matrix, and Rtis the transmit correlation matrix. [15].

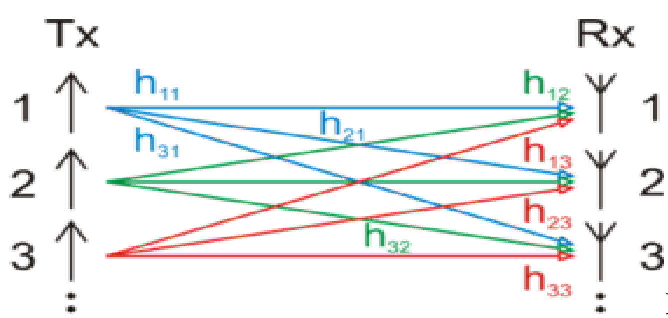

Figure: 3.15: MIMO Channel Modeling

3.6 Multipath Fading

Multipath fading occurs not surprisingly when there are multiple propagation paths between the transmitter and receiver this can occur when the medium such as the

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atmosphere or ocean is no homogeneous causing reactions and bending the paths of propagation or when nearby obstacles produce reactions Because he distance along each path can be divergent the receiver sees multiple delayed versions of the transmitted signal.

Slow fading arises when the coherence time of the channel is large relative to the delay constraint of the channel. In this regime, the amplitude and phase change imposed by the channel can be considered roughly constant over the period of use. Slow fading can be caused by events such as shadowing, where a large obstruction such as a hill or large building obscures the main signal path between the transmitter and the receiver.

Fast fading occurs when the coherence time of the channel is small relative to the delay constraint of the channel. In this regime, the amplitude and phase change imposed by the channel varies considerably over the period of use [15].

3.7 Rayleigh Fading

Rayleigh fading occurs on time varying multipath channels this can occur when the medium is time varying such as undersea acoustic transmission radio transmission through the upper atmosphere and indo or radio transmission where moving people cast shadows or it can occur when the transmitter and receiver are in motion as in mobile radio.

If there is no dominant component to the scatter, then such a process will have zero mean and phase evenly distributed between 0 and 2π radians. Theenvelope of the channel response will therefore be Rayleigh distributed.

Calling this random variable R, it will have a probability density function:

$$R(r) = \frac{2r}{\Omega} e^{\frac{-r^2}{\Omega}}, r \geq 0 \quad \text{..........} \quad (3.4)$$

Where, $\Omega = E(R^2)$.

.

Often, the gain and phase elements of a channel's distortion are conveniently represented as a complex number. In this case, Rayleigh fading is exhibited by the assumption that the real and imaginary parts of the response are modeled by independent and identically distributed zero-mean Gaussian processes so that the amplitude of the response is the sum of two such processes[13].

3.8 Rician fading

Rician fading is a stochastic model for radiopropagation anomaly caused by partial cancellation of a radio signal by itself — the signal arrives at the receiver by several different paths (hence exhibiting multipath interference), and at least one of the paths is changing (lengthening or shortening). Rician fading occurs when one of the paths, typically a line of sight signal, is much stronger than the others. In Rician fading, the amplitude gain is characterized by a Rician distribution [15].

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CHEAPTER 4: PERFORMANANCE ANALYSIS

4.1 Overview

This chapter consists with the comparison of different types of smart antenna in various cases. Performances of SISO, SIMO, MISO, and MIMO are determined by Shannon Capacity law. For MIMO we will represent different antenna combination and find out the channel capacity for each combination. The BER also determined by the block set in multipath fading channel. The FER is measured by block set in multipath fading channel in QPSK modulation technique & M-PSK modulation technique respectively for Alamouticoding. Then the performances of each antenna are compared to find out which one is best.

4.2 Channel Capacity

Claude Shannon first derived the channel capacity for additive white Gaussian noise (AWGN) channels in 1948. Compared with the scalar AWGN channels, a MIMO system can offer significant improvement to either communication quality (bit-error rate or BER)or transmission date rate (bits/sec) by exploiting spatial diversity . This section begins with fundamental results, which compares single-input single-output (SISO), single-input-multiple-output (SIMO) and multiple input-single-output (MISO) systems [15].

4.2.1 SISO Channel Capacity

For a memory less SISO (Single-Input-Single-Output) system the capacity is given by [4]

$$C_{SISO}= \log_2(1+r|h|^2) \text{ bps/Hz} \quad \ldots\ldots\ldots\ldots..(4.1)$$

Where, r is the SNR at receiver antenna, and H is the normalized complex gain of the channel

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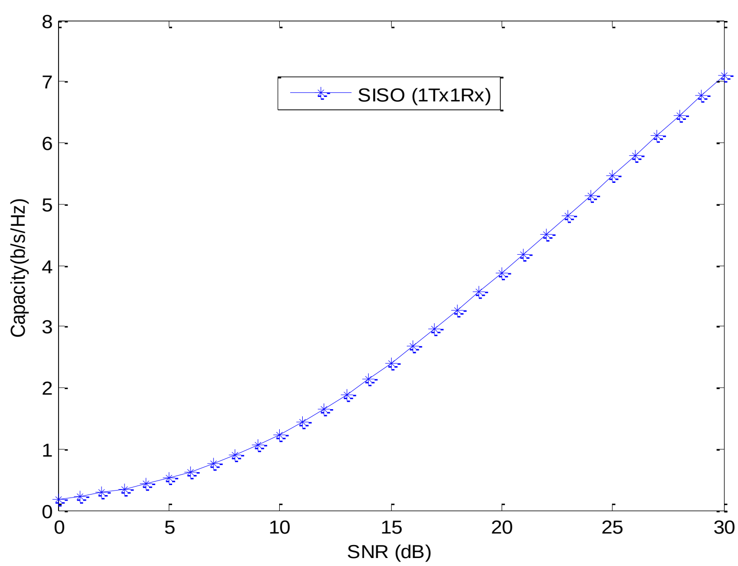

Figure: 4.1: Channel capacity of SISO.

4.2.2 SIMO System Capacity

With *NR* RX antennas, the single-input-multiple-output (SIMO) system capacity is [4]

$$C_{SIMO} = \log_2\left(1+\rho\sum_{m=1}^{N_R}|h_m|^2\right) bps/Hz \quad ....(4.2)$$

Where *hm* is the gain for *Cmth*RX antenna.

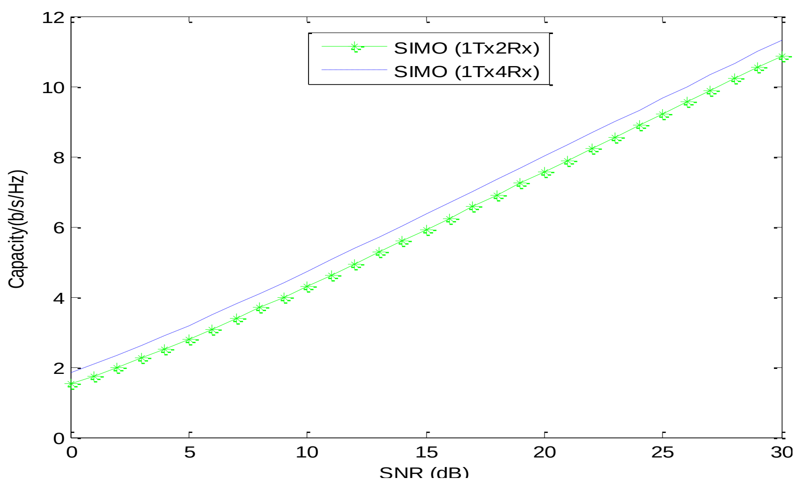

Figure: 4.2: Channel capacity of SIMO.

4.2.3 MISO Channel Capacity

However, if *NT* TX antennas are used, a multiple-input-single-input (MISO) is achieved.

The capacity is given [4]

$$C_{MISO} = \log_2\left(1+\frac{\rho}{N_T}\sum_{n=1}^{N_T}|h_n|^2\right) bps/Hz \quad ....(4.3)$$

.

Where*hn*is the gain for *nth* TX antenna. In order to ensure transmitter power restriction, SNR is normalized by *NT* .

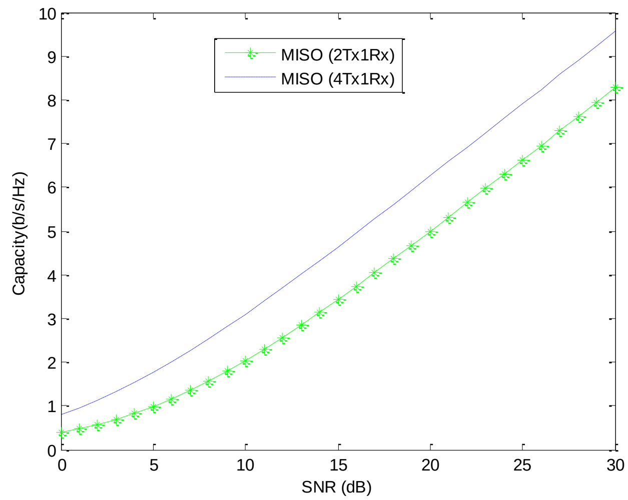

Figure: 4.3: Channel capacity of MISO.

4.2.4 MIMO Channel Capacity

We assume a transmitter array with M and a receiver array with N antennas in a frequency flat-fading MIMO channel. Denoting the input signal as x and the output of the channel as y, we have the relation

y = Hx + n (1)………………..(4.4)

where H is the N & M MIMO channel matrix and n an additive white gaussian noise. The capacity C of such a channel is known to be [9].

$$C = \max_{Tr(R_{xx})=M} \log_2 \det\left(I_N + \frac{\rho}{M} H R_{xx} H^H \right) \text{..........(4.5)}$$

where IN is the identity matrix of size N, pis the signal to-noise ratio, and Rxx= E[xxH] with E[:] being the expectation, (:)H the conjugate transpose of a matrix, and Tr(:) the trace operator; det(:) denotes the determinant andlog2(:) the logarithm to base 2. The channel matrix H has correlated random entries. The correlation matrix is

RH = E[vec(H)vec(H)H]…………..(4.6)

.

Where vec(.) is the columns vectorizing operator. The correlation matrix RH describes all correlations within the channel, i.e. both space and antenna correlation. The antennas are part of the channel. For MIMO the channel capacity is

$$\text{Channel Capacity} = \text{Antennae} \times \text{Bandwidth} \times \log_2(1 + \text{SNR})$$

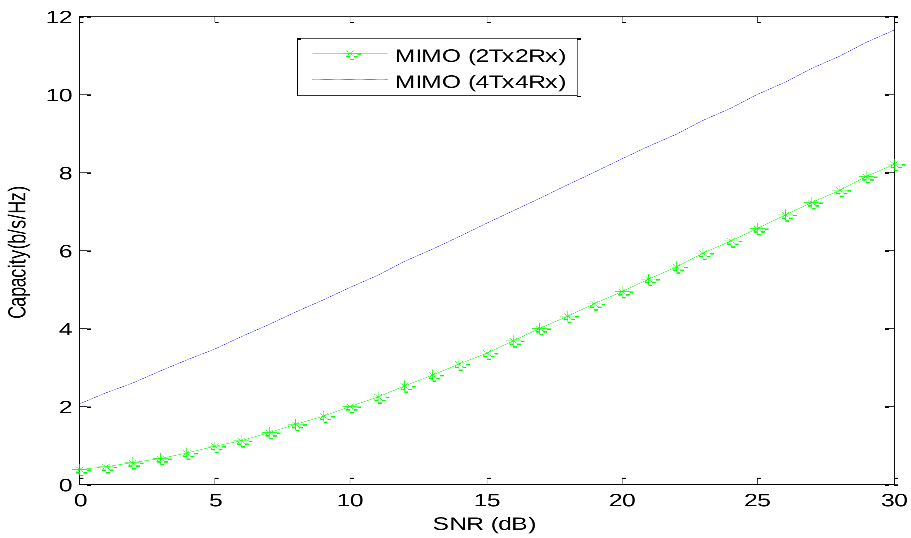

Figure: 4.4: Channel capacity of MIMO.

4.2.5 SISO, SIMO, MISO, MIMO Channel Capacity Compare

Now we see the performance analysis graph for different number of antenna.

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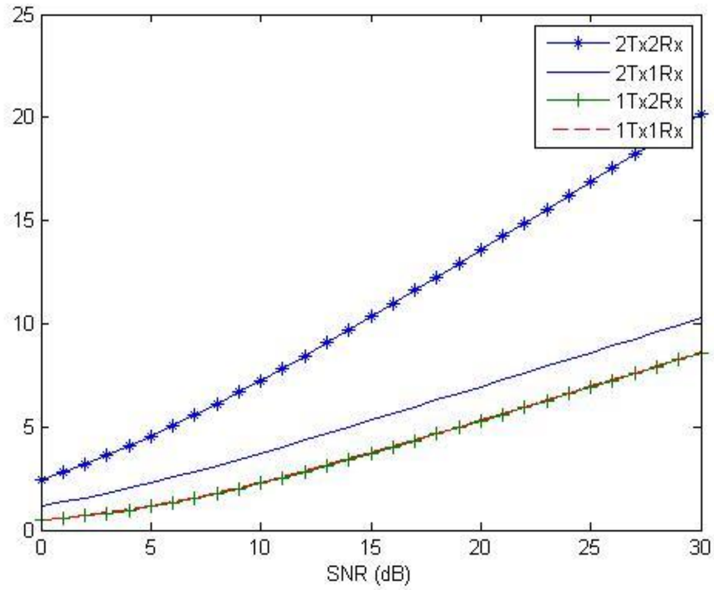

Figure: 4.5: Comparing the capacity of SISO, MISO, SIMO, MIMO.

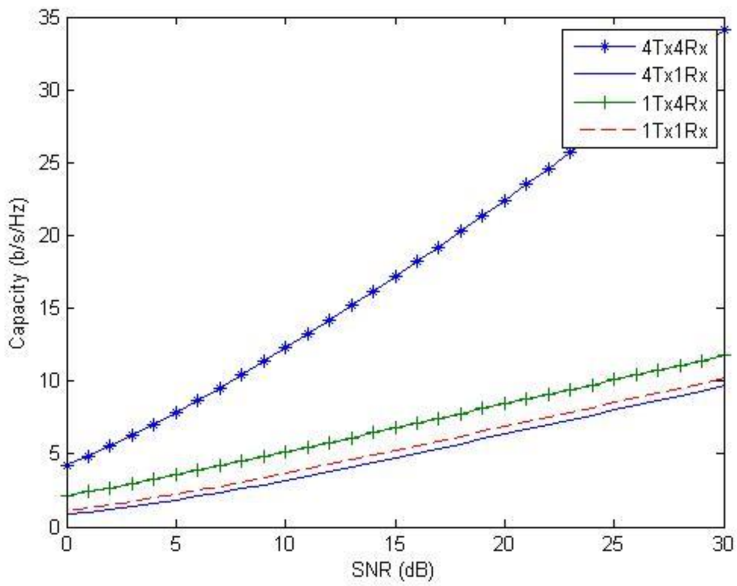

Figure: 4.6: Comparing the capacity of SISO, MISO, SIMO, MIMO.

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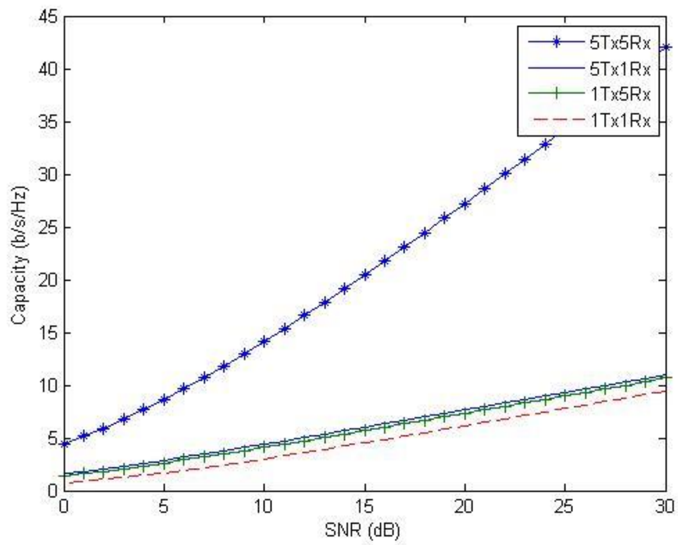

Figure: 4.7: Comparing the capacity of SISO, MISO, SIMO, MIMO.

SNR using Equation From the figure, we can see that the SIMO & MISO channels improve the capacity compared with the SISO channel by exploiting more antennas. However, the SIMO and MISO channels can only offer a logarithmic increase in capacity with the number of antennas. Comparing Equation and it is clear that

. $C_{MISO} < C_{SIMO} < C_{MIMO}$

So it is confirmed that MIMO antenna is best between them. Now we represent a comparative difference above all of them.

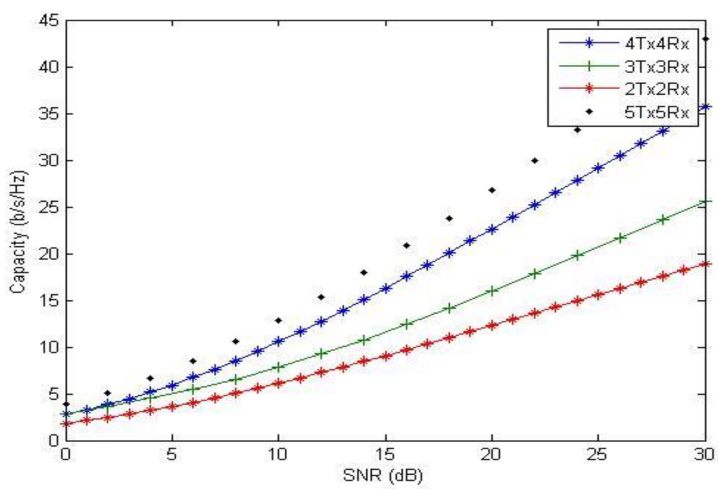

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Figure: 4.8: Comparing the capacity of different combination of MIMO.

As we defined in previous chapter channel capacity is the maximum rate at which we can send data over the channel and recovery the data at the output with vanishing probability error. Channel capacity depend on signal noise ratio (SNR), in Number of antenna element (in MIMO), in bandwidth (for band limited channel).

Now we will see the simulation result for theoretical Shannon's channel capacity for Rayleigh fading channel with compare to MIMO.

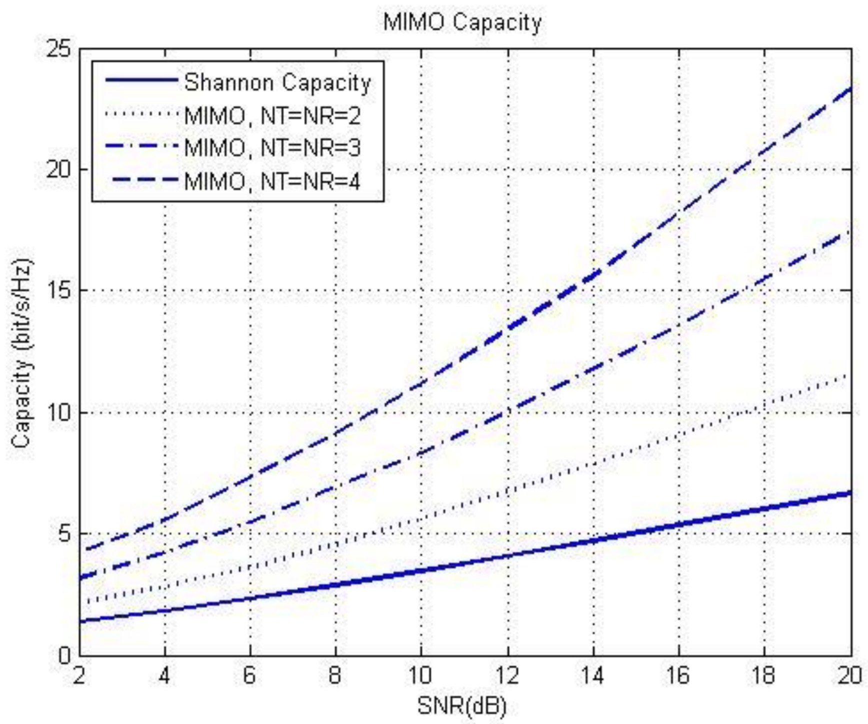

Figure: 4.9: Comparing the Shannon's capacity of & MIMO.

In Fig 4.5 below we can see that when we increase the SNR, the average channel capacity increases too. But practically we can increase the SNR ratio only to certain limit because of system radiation power limitation and cost and size of the equipment to implement the system.

In MIMO if the number of antenna element grows the capacity will increase. It increases linearly in proportion to large number of antenna elements.

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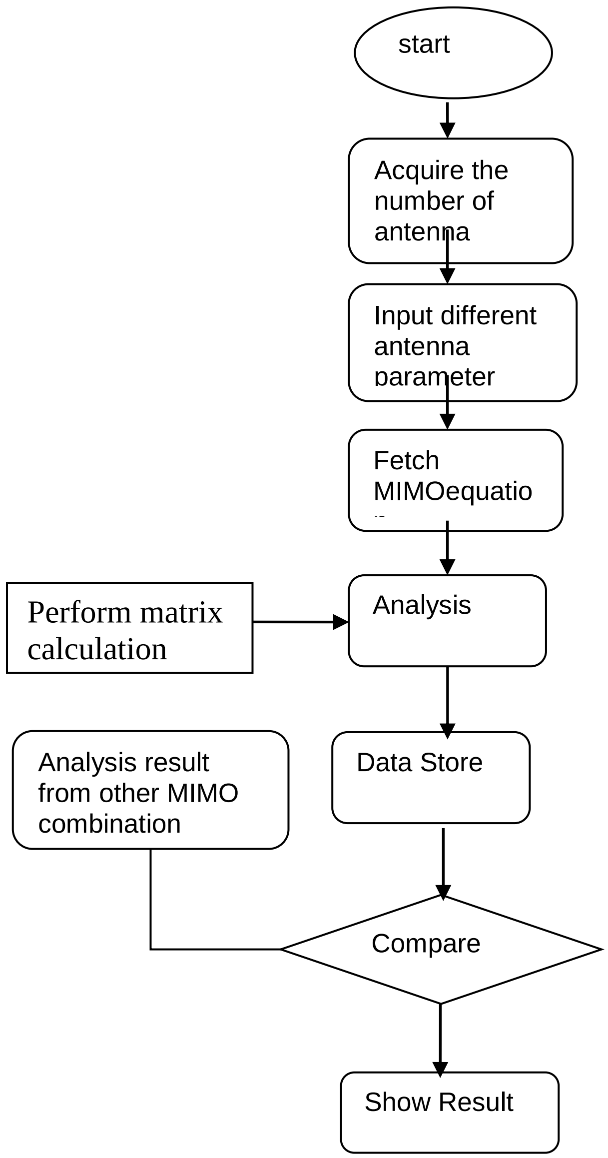
4.3 Overall Simulation Process



Flowchart 4.1: Overall Simulation Process

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4.4 Real Field Data Base For 2*2 MIMO Channel

Motorola a leading telecom brand now this time. Canopy is a smart antenna from Motorola. It is use in different Internet Service Provider (ISP) in our country.

Now we represent the channel capacity for different fading channel from real world by using the Motorola canopy smart antenna.

- With MIMO in Rayleigh Fading channel
- Without MIMO in Rician fading channel

For example

Session Status List

LUID: 002 : MAC: 0a-00-3e-f8-38-97 State: IN SESSION (Encrypt Disabled)
Site Name : BTSLNK_DHK02toDHK18_BL05_EL01
Software Version : CANOPY 8.2
Software Boot Version : CANOPYBOOT 3.0
FPGA Version : 060407 (DES, Sched, US/ETSIv1.3.1) P9
Session Timeout: 25, AirDelay 157 (approximately 1.46 miles (7693 feet))
Session Count: 2, Reg Count 2, Re-Reg Count 0
RSSI (Avg/Last): 2076/2085 Jitter (Avg/Last): 6/7 Power Level (Avg/Last): -39/-38
Low Priority Uplink CIR (SM): 0 (kbps) Low Priority Downlink CIR (SM): 0 (kbps)
PToP VLAN: SUPPORTED Rate : VC 18 Rate 2X/2X VC 255 Rate 2X/2X

Fig 4.10: Different antenna parameter with MIMO(2*2) Technology [16]

.

LUID: 003 : MAC: 0a-00-3e-51-32-b6 State: IDLE
Site Name : Scope Project
Session Timeout: 0, AirDelay 7 (approximately 0.06 miles (343 feet))
Session Count: 4, Reg Count 4, Re-Reg Count 0
RSSI (Avg/Last): 1779/1777 Jitter (Avg/Last): 8/9 Power Level (Avg/Last): -39/-39
Sustained Uplink Data Rate (AP): 20000 (kbit)
Uplink Burst Allocation (AP): 500000 (kbit)
Sustained Downlink Data Rate (AP): 20000 (kbit)
Downlink Burst Allocation (AP): 500000 (kbit)
Low Priority Uplink CIR (D): 0 (kbps) Low Priority Downlink CIR (D): 0 (kbps)
Rate : VC 19 Rate 1X/1X

Fig 4.11: Different antenna parameter with SISO(1*1) Technology [16]

From the figure 4.11 we can easily find some parameter like as

- **Receive Signal Strength Indicator (RSSI)**
- **Jitter**
- **Power Level**
- **Air Distance**
- **Bandwidth**
- **Coverage Area**

4.4.1 Receive Signal Strength Indicator (RSSI)

Now we see the RSSI value for the SISO Technology in Rician fading channel.

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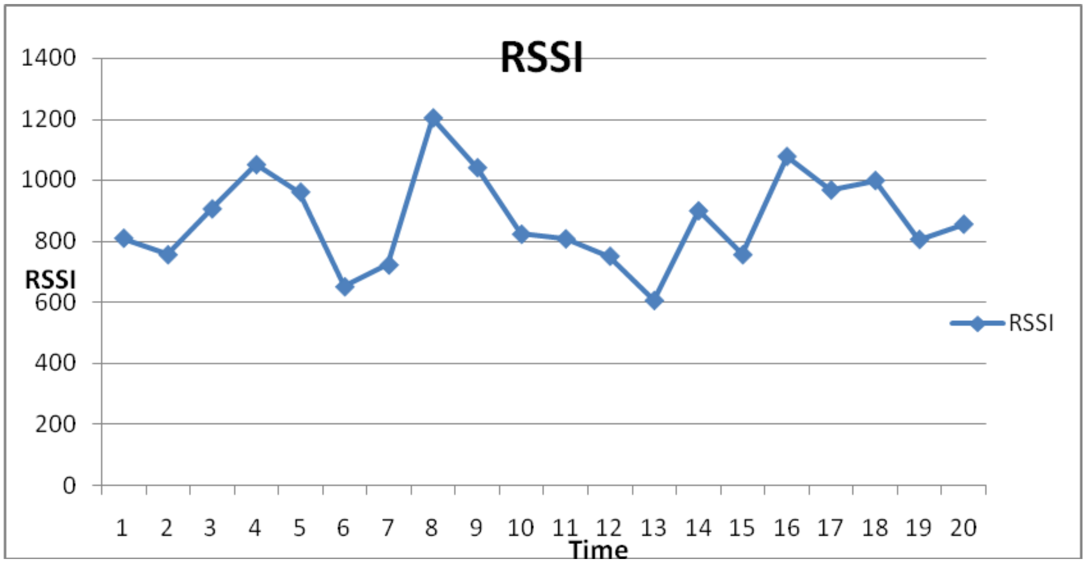

Figure 4.12 : RSSI value for SISO channel [16]

In the figure X-axis show's the time and Y-axis show the RSSI value.We take the value of RSSI for twenty minute. Every one minute time interval RSSI value is vary from 650 to 1200 in SISO system[16].

Now we see the RSSI value for the MIMO in Rayleigh Fading channel

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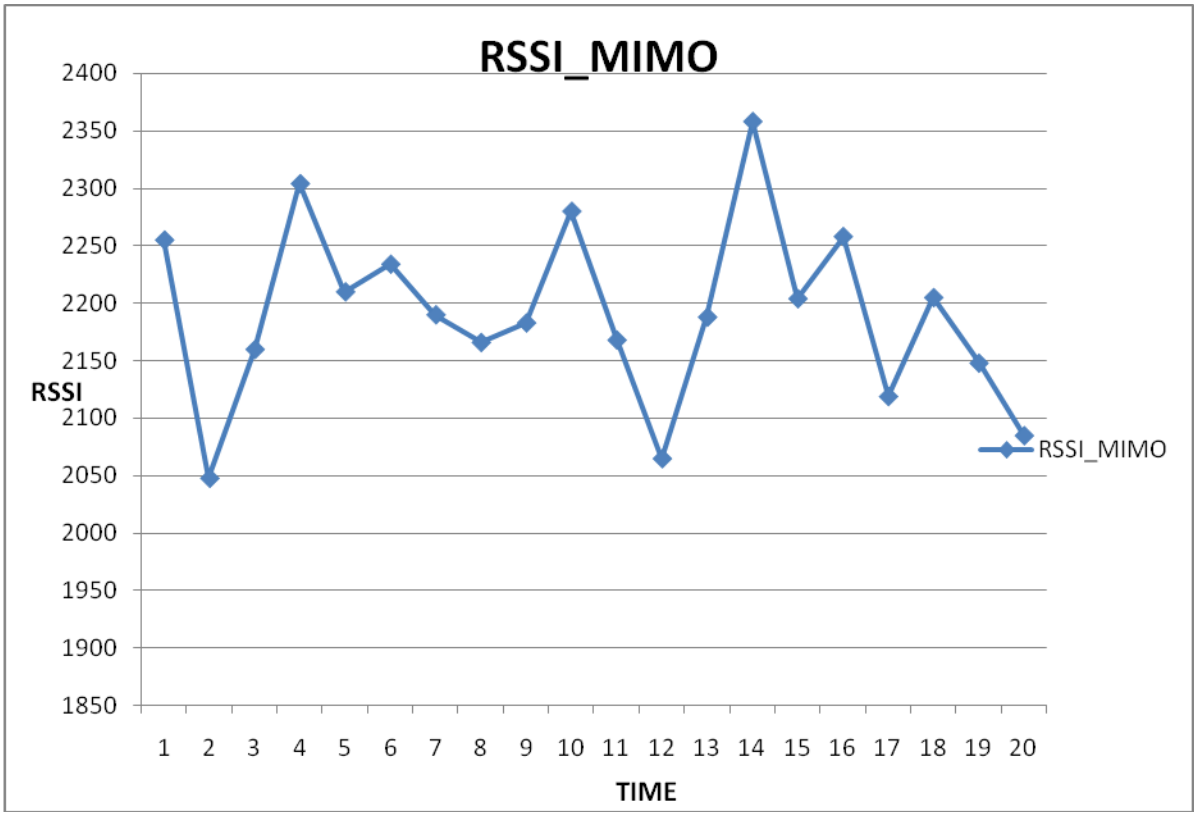

Figure 4.13 : RSSI value for MIMO channel [16]

In the figure X-axis show's the time and Y-axis show the RSI value. We see that the RSSI value is vary from 2048 to 2358 in MIMO technology. SO MIMO is much better then the SISO[16].

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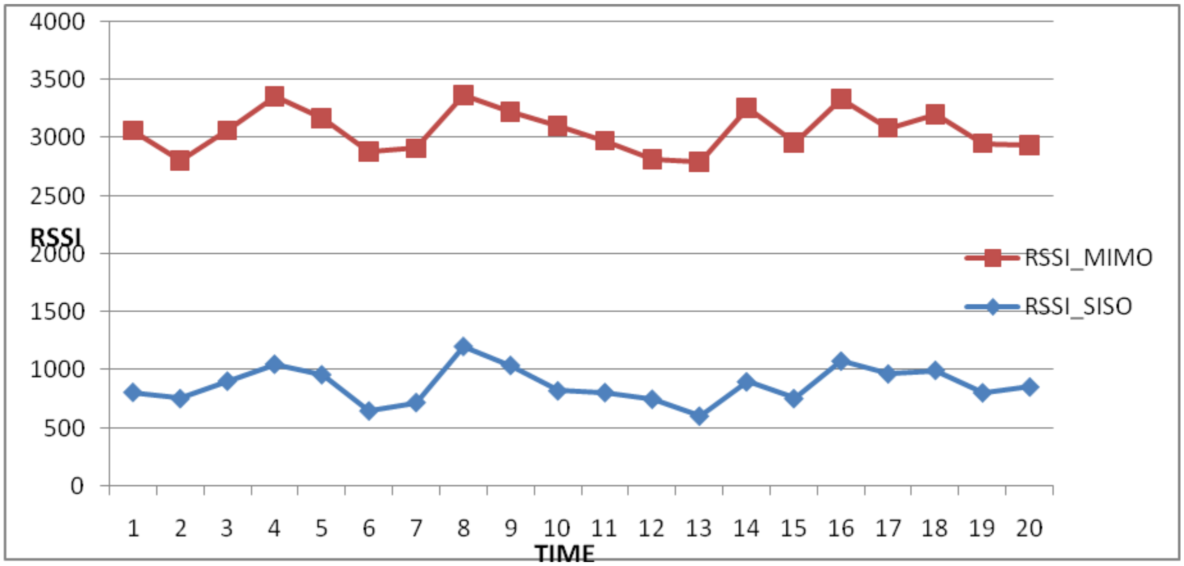

Figure 4.14: MIMO Vs SISO in terms of RSSI value [16]

4.4.2 Jitter

Jitter is the undesired deviation from true periodicity of an assumed periodic signal in electronics and telecommunications, often in relation to a reference clock source. Jitter may be observed in characteristics such as the frequency of successive pulses, the signal amplitude, or phase of periodic signals. Jitter may be caused by electromagnetic interference (EMI) and crosstalk with carriers of other signals. Jitter can cause a display monitor to flicker, affect the performance of processors in personal computers, introduce clicks or other undesired effects in audio signals, and loss of transmitted data between network devices.

We see that the jitter is rapidly change in SISO but normally in MIMO. For SISO if the jitter is 1 to 4 the it is considerable but if it cross this margin line then the signal is not efficient. As well as this is same for MIMO but the range is 1 to 8. SO MIMO is much better then the SISO[16].

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4.4.3 Power Level

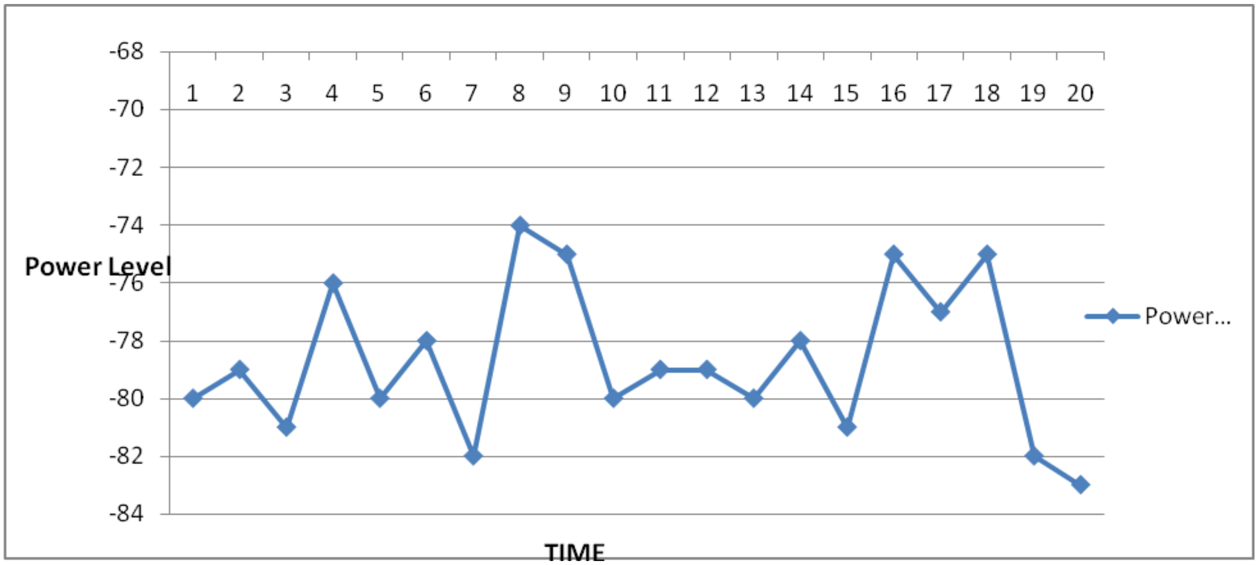

Figure 4.15 : Power Level for SISO channel [16]

In the figure X-axis show's the time and Y-axis show thePower Level. This is for SISO System[16].

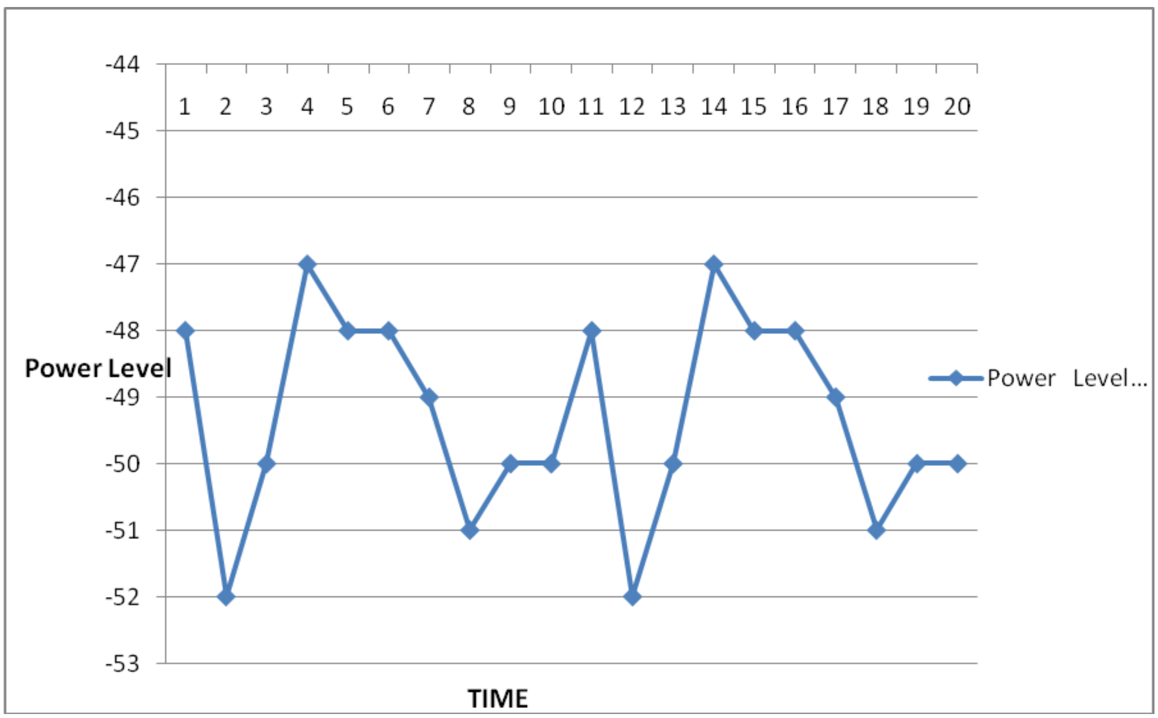

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Figure 4.16 : Power Level for MIMO channel

In the figure X-axis show's the time and Y-axis show thePower Level. This is for MIMO System[16].

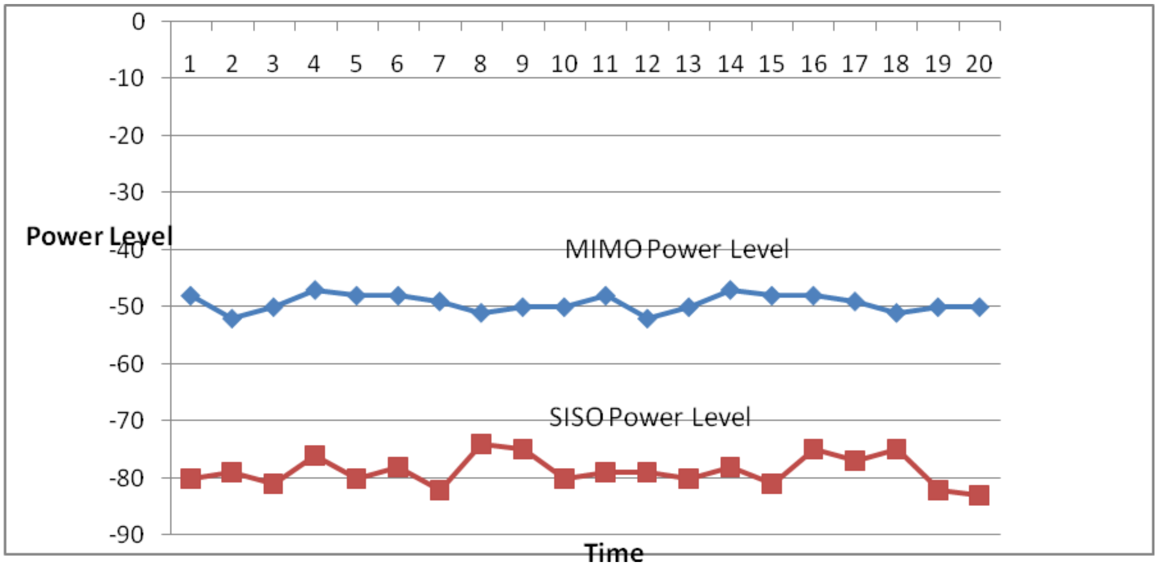

Figure 4.17 : MIMO Vs SISO in terms of Power Level

Figure 4.17 show the power level compara graph for MIMO and SISO. We see tha the power level of MIMO is much lower then the SISO. SO MIMO give us better performance as compare the SISO [16].

4.4.4 Bandwidth

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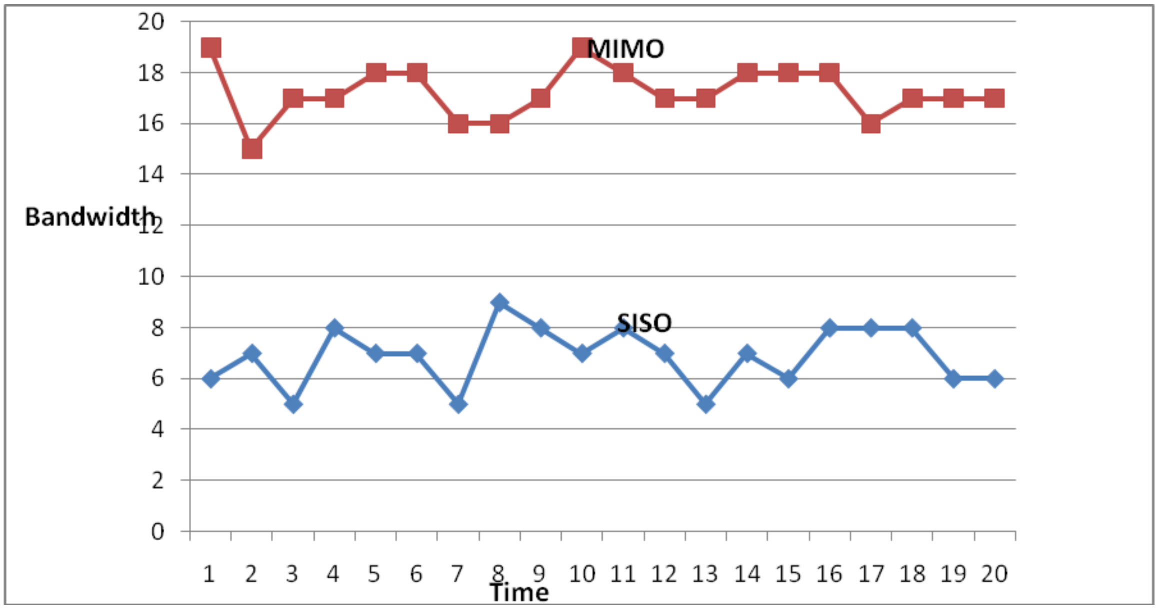

Figure 4.18 : MIMO Vs SISO in terms of Bandwith.

Bandwith is the main key factor for channel capaciry. In the figure 4.18 X-axis show's the time and Y-axis show the bandwith. Here we collect the data for twenty minute at every one minute interval. In the graph we see that the MIMO give's us almost double data rate as compare to SISO. It is similar to our Matlab simulation result. SO MIMO is much better then the SISO in term's of data throuput [16].

4.4.5 Coverage Area

MIMO technology has also attached the attention in the coverage area. If we use SISO technique on the Access Point (AP). Then the coverage area is much lower than the MIMO Access Point. For example if we use the MIMO Access Point foe our existing cell then it can give us almost double coverage area. From the figure we use MIMO AP on Gulshan BTS. But if we search the frequency on the Uttara BTS then we can easily find

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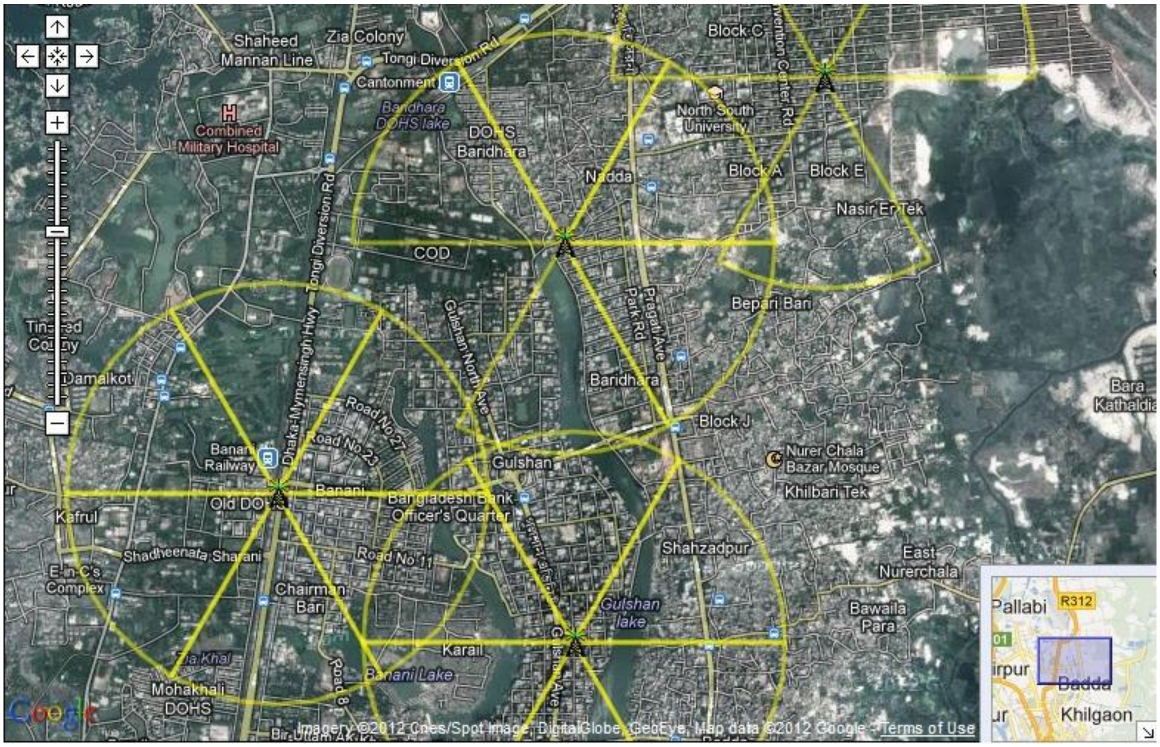

Fig 4.19: Cell planning of X-Net Ltd

That AP with good signal strength. But for the other's AP it is not possible. So MIMO Antenna can break our existing cell planning. SO MIMO give us better performance then the SISO in term's of coverage area [16].

4.5 BER:

In digital transmission, Bit error rate (BER) is the percentage of bits that have errors relative to the total number of bits received in a transmission, usually expressed as ten to a negative power[17]. For example, a transmission might have a BER of $2x10^{-6}$, meaning that, out of 1,000,000 bits transmitted, two bit was in error. Bit error rate (BER) is used in as a figure of merit for how effectively the receiver is able to decode transmitted data. It is an indication of how often a packet or other data unit has to be retransmitted because of an error. Too high a BER may indicate that a slower data rate would actually improve overall transmission time for a given amount of transmitted data since the BER might be reduced, lowering the number of packets that had to be resent. BER is a unit less performance measure, often expressed as a percentage[17].

4.6 Factors affecting BER

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The receiver side BER is basically affected by transmission side noise, interference, distortion, attenuation, wireless multipath fading etc in a communication system.

The BER may be improved by choosing strong signal strength, by choosing a slow and robust modulation scheme or line coding scheme, and by applying channel coding schemes such as redundant forward error correction codes[17].

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4.7 Calculating BER

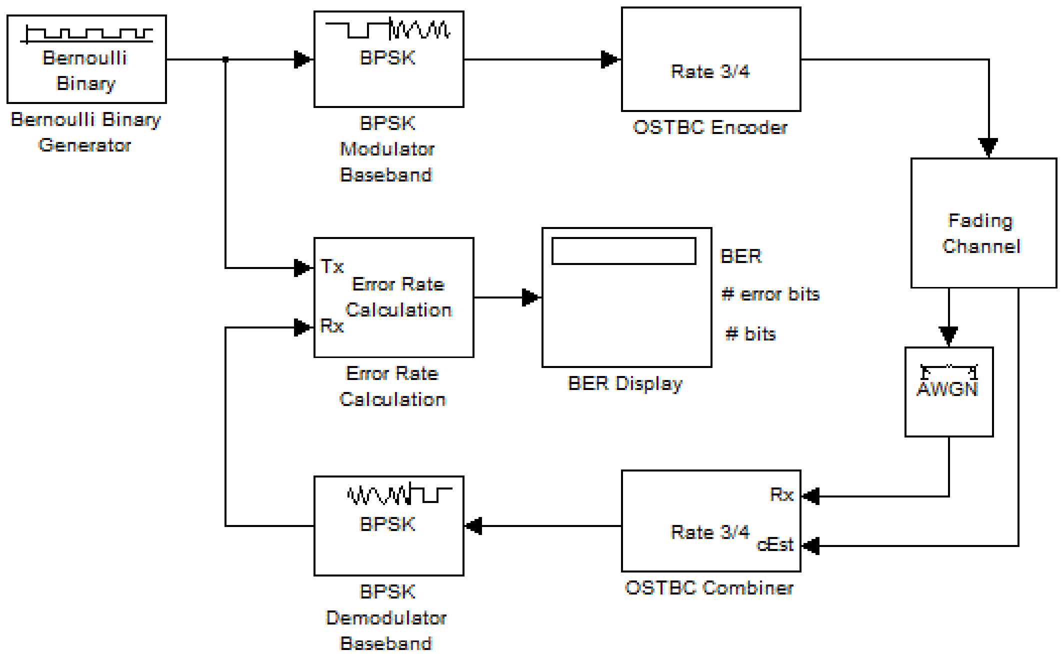
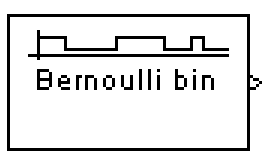


Figure 4.20 : Block diagram for BPSK modulation.

The figure 4.20 is a block diagram which is used to determine the BER. This diagram shows that it consists with some block set. The short description about the block set is given below.

4.7.1 Bernoulli Binary generator

This block model generates the random data using the Bernoulli Binary generator which generates data bits by uniform distribution. The random source generates a continuous waveform which is sampled to convert to frames.



4.7.2 BPSK Modulator Baseband

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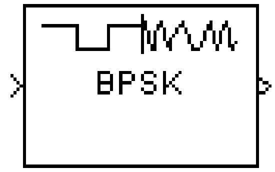
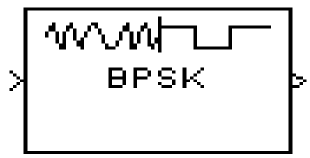
The BPSK Modulator Baseband block modulates using the binary phase shift keying method. The output is a baseband representation of the modulated signal. The input must be a discrete-time binary-valued signal. This block can output an up sampled version of the modulated signal.



4.7.3 BPSK Demodulator Baseband

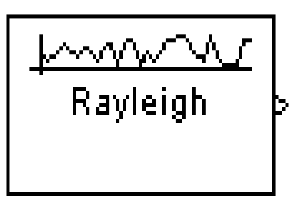
The BPSK Demodulator Baseband block demodulates a signal that was modulated using the binary phase shift keying method. The input is a baseband representation of the modulated signal. The input can be either a scalar or a frame-based column vector.



4.7.4 Rayleigh Fading Channel Block Set

Since a multipath channel reflects signals at multiple places, a transmitted signal travels to the receiver along several paths that may have different lengths and hence different associated time delays. Fading occurs when signals traveling along different paths interfere with each other.

The Multipath Rayleigh Fading Channel block implements a baseband simulation of a multipath Rayleigh fading propagation channel. This block is useful for modeling mobile wireless communication systems. The input can be either a scalar or a frame-based column vector. The input is a complex signal.



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4.7.5 Rician Fading Channel Block Set

The Multipath Rician Fading Channel block implements a base band simulation of a multipath Rician fading propagation channel. This block is used to model mobile wireless communication systems when the transmitted signal can travel to the receiver along a dominant line-of-sight or direct path.

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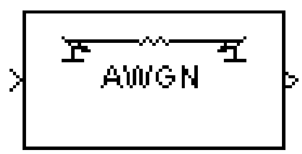
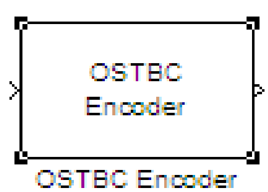
4.7.6 AWGN

The AWGN Channel block adds white Gaussian noise to a real or complex input signal. When the input signal is real, this block adds real Gaussian noise and produces a real output signal. When the input signal is complex, this block adds complex Gaussian noise and produces a complex output signal. This block inherits its sample time from the input signal.



4.7.7 OSTBC Encoder

This block encodes an input symbol sequence by means of orthogonal space-time block code (OSTBC). The block maps the input symbols block-wise and concatenates the output codeword matrices in the time domain. This block encodes the information symbols from the QPSK/M-PSK Encoder by using the Alamouti code for 2 transmit antennas.



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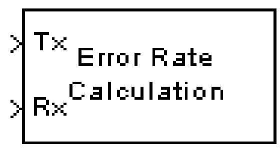
4.7.8 OSTBC Combiner

The OSTBC Combiner block combines the input signal (from all of the receive antennas) and the channel estimate signal to extract the soft information of the symbols encoded by an OSTBC. The input channel estimate may not be constant during each code word block transmission and the combining algorithm uses only the estimate for the first symbol period per code word block.

OSTBC Combiner

4.7.9 Error Rate Calculation Block Set

The Error Rate Calculation block compares input data from a transmitter with input data from a receiver. It calculates the error rate as a running statistic, by dividing the total number of unequal pairs of data elements by the total number of input data elements from one source.

This block is used to compute either symbol or bit 

error rate, because it does not consider the magnitude of the difference between input data elements. If the inputs are bits, then the block computes the bit error rate. If the inputs are symbols, then it computes the symbol error rate.

This block has between two and four input ports, depending on how set the mask parameters. The in ports marked Tx and Rx accept transmitted and received signals, respectively. The Tx and Rx signals must share the same sampling rate.

Below we get a handful of data for BER in two different fading channels and in BPSK modulation technique,

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Fading Channel	No. of (Tx)	No. of (Rx)	Antenna types	Number of error bit	No. of Bits	BER	Approximate (%) of BER
Rayleigh	3	1	MISO	100	1638	0.06105	6.1
	3	3	MIMO	100	$2.296x10^4$	0.004356	0.4
	4	1	MISO	100	972	0.1029	10.3
	4	2	MIMO	100	1974	0.05066	5.1
Rician	3	1	MISO	100	1293	0.07734	7.7
	3	3	MIMO	100	4266	0.02344	2.4
	4	1	MISO	101	2685	0.03762	3.8
	4	2	MIMO	100	1041	0.09606	9.6

Table 4.1: BER Calculation for Rayleigh and Rician fading channel.

4.7.10 Comparison for Rayleigh fading channel

In Rayleigh fading channel a block set is introduced for MISO (TxR, 3x1). BPSK modulation technique is used in this case. Here number of transmit bits is 1638, number of error bits is 100. It shows that BER for this case is almost 6.1%.

In Rayleigh fading channel a block set is introduced for MIMO (TxR, 3x3). BPSK modulation technique is used in this case. Here number of transmit bits is $2.296x10^4$, number of error bits is 100. It shows that BER for this case is almost .4%.

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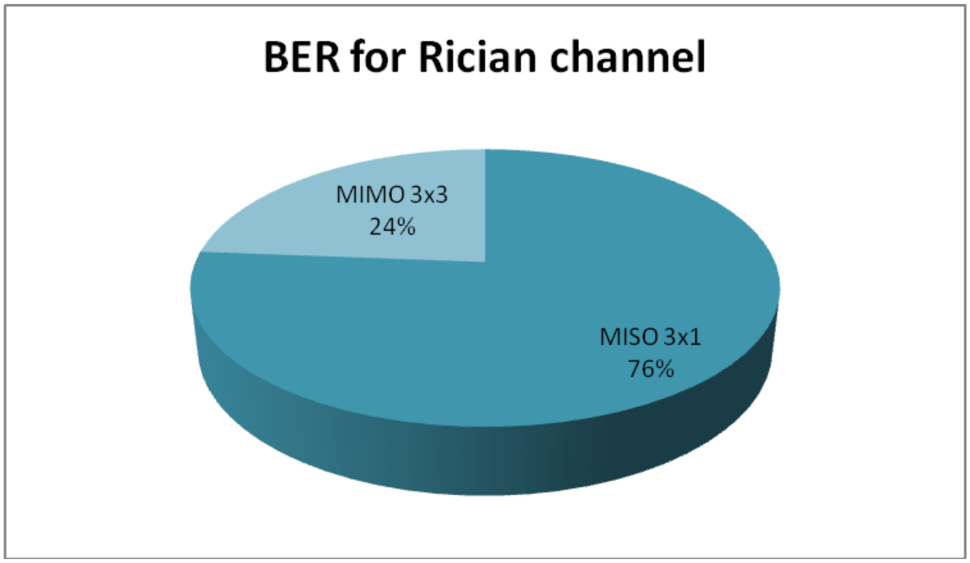

Fig. 4.21 : Pie chart for MISO(3x1) and MIMO(3x3)

Again, In Rayleigh fading channel a block set is introduced for MISO (TxR, 4x1). BPSK modulation technique is used in this case. Here number of transmit bits is 972, number of error bits is 100. It shows that BER for this case is almost 10.3%

In Rayleigh fading channel a block set is introduced for MIMO (TxR, 4x2). BPSK modulation technique is used in this case. Here number of transmit bits is 1293, number of error bits is 100. It shows that BER for this case is almost 5.1%.

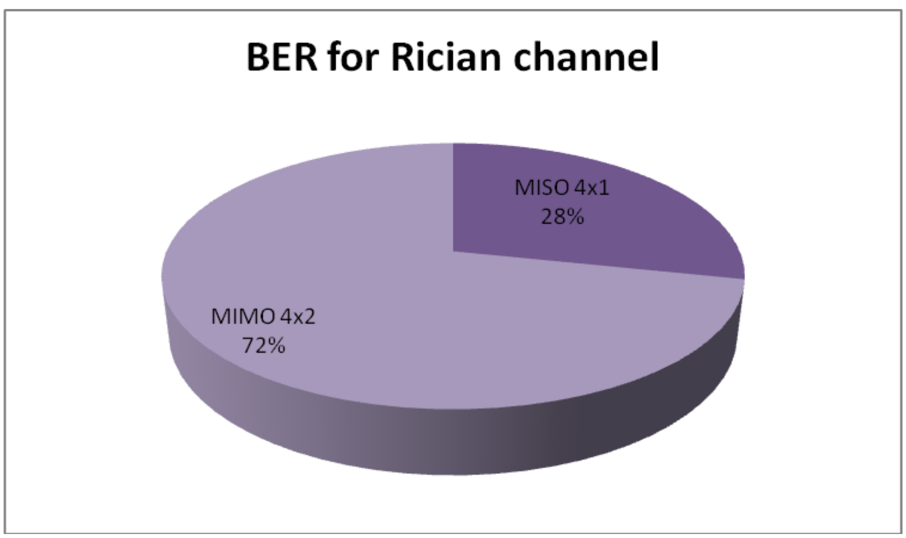

Fig 4.22: Pie chart for MISO(4x1) and MIMO(4x2)

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It is clearly seen from figure 4.21 and 4.22 that in both cases BER for MIMO is the lowest.

4.7.11 Comparison for Rician fading channel

In Rician fading channel a block set is introduced for MISO (TxR, 3x1). BPSK modulation technique is used in this case. Here, if considered number of error bits is 100 than number of transmits bit is 1293. It shows that percentage of BER is almost 7.7

In Rician fading channel a block set is introduced for MIMO (TxR, 3x3). BPSK modulation technique is used in this case. Here, if considered number of error bits is 100 than number of transmits bit is 4266. It shows that percentage of BER is almost 2.3

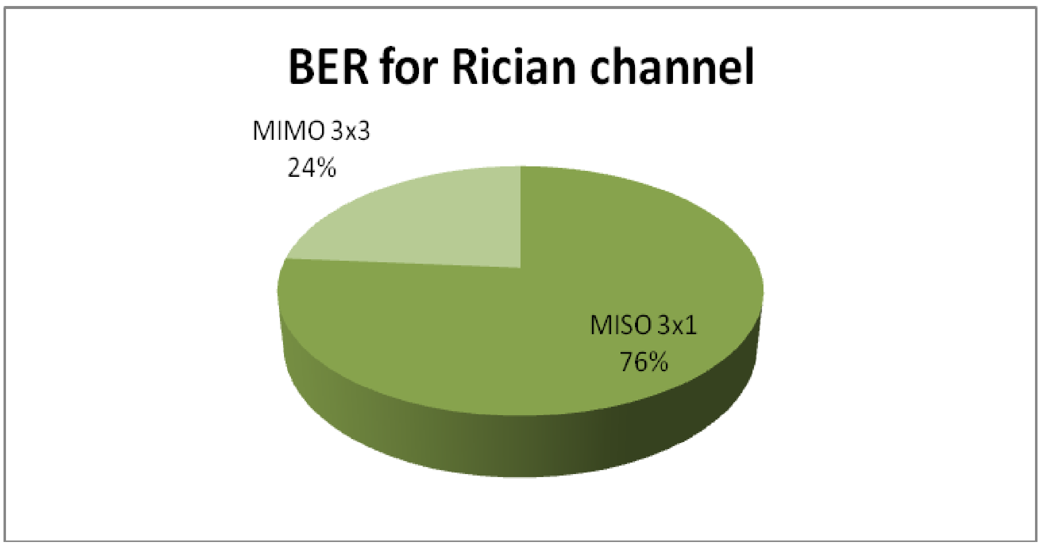

Figure 4.23: Pie chart for BER in Rician.

Here BER of MIMO (TxR, 3x3) is lower than MISO (TxR, 3x1) in Rician channel.

Again, in Rician fading channel a block set is introduced for MISO (TxR, 4x1). BPSK modulation technique is used in this case. Here, if considered number of error bits is 101 than number of transmits bit is 2685. It shows that BER is almost 3.8%.

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In Rician fading channel a block set is introduced for MIMO (TxR, 4x2). BPSK modulation technique is used in this case. Here, if considered number of error bits is 100 than number of transmits bit is 1041. It shows that BER is almost 9.6%.

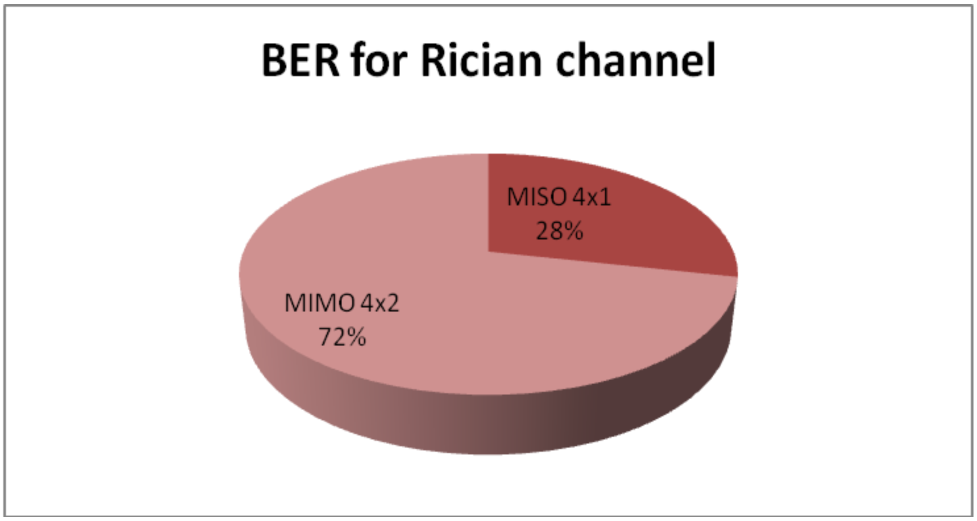

Figure 4.24: Pie chart for BER in Rician.

Here BER of MISO (TxR, 4x1) is lower than MIMO (TxR, 4x2) in Rician channel. Though the BER of MISO was greater in 1st Pie chart, it seems lower in the 2nd one.

4.8 FER

FER is the ratio of data received with errors to total data received. It is used to determine the quality of a signal connection. The measurement is used to test the performance of a mobile station's receiver. If the FER is too high (too many errors), the connection may be dropped. Like BER, FER is a unit less performance measure, often expressed as a percentage.

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4.9 FER calculation for M-PSK Alamouti

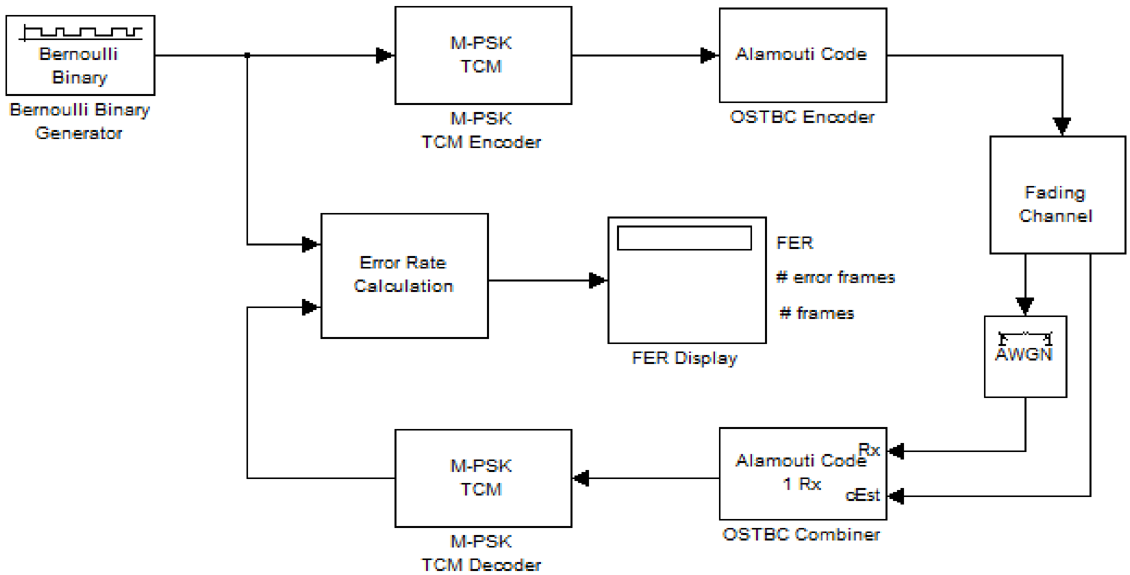

Figure: 4.25: Block diagram for M-PSK TCM Alamouti.

In this case the two new tools kid added. They are M-PSK TCM Encoder and M-PSK TCM Decoder.

4.9.1 Alamouti Scheme

Alamouti Scheme is a simple space–time block code scheme suitable for two transmit antenna system, although it was not the term "space–time block code" before. Before coding into Alamouti, the base band signal would be modulated in M-PSK modulation scheme at every transmit antenna. Then the modulated signal is encoded by STBC technique.

4.9.2 M-PSK Encoder

The M-PSK TCM Encoder block implements trellis-coded modulation (TCM) by convolutionally encoding the binary input signal and mapping the result to a PSK signal constellation.This block accepts a binary-valued input signal. The output signal is a complex column vector of length.

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4.9.3 M-PSK Decoder

The M-PSK TCM Decoder block uses the Viterbi algorithm to decode a trellis-coded modulation (TCM) signal that was previously modulated using a PSK signal constellation.

This block accepts a column vector input signal containing complex numbers. The input signal must be double or single. The reset port signal must be double or Boolean.The table below was formed based on simulation,

Modulation Technique	Fading Channel	No. of (Tx)	No. of (Rx)	Antenna types	Number of error frames	No. of Frames	FER	Approximate (%) of FER
M-PSK TCM	Rayleigh	2	1	MISO	1000	5357	0.1867	18.67
		2	2	MIMO	1000	68027	0.0147	1.473
	Rician	2	1	MISO	1000	18040	0.0554	5.54
		2	2	MIMO	1000	58810	0.017	1.7

Table 4.2: FER Calculation for Rayleigh and Rician fading channel.

In Rayleigh, this case considered the number of transmit antenna is two and the number of receive antenna is one. Here, the FER is measured only when considered the number of error frame is 1000. QPSK modulation technique is used in this case. The percentage of FER for Alamouti (2x1) is almost 18.67.

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In this case considered the number of transmit antenna is two and the number of receive antenna is one. Here, the FER is measured only when considered the number of error frame is 1000. QPSK modulation technique is used in this case. The percentage of FER for Alamouti (2x2) is only 1.473.

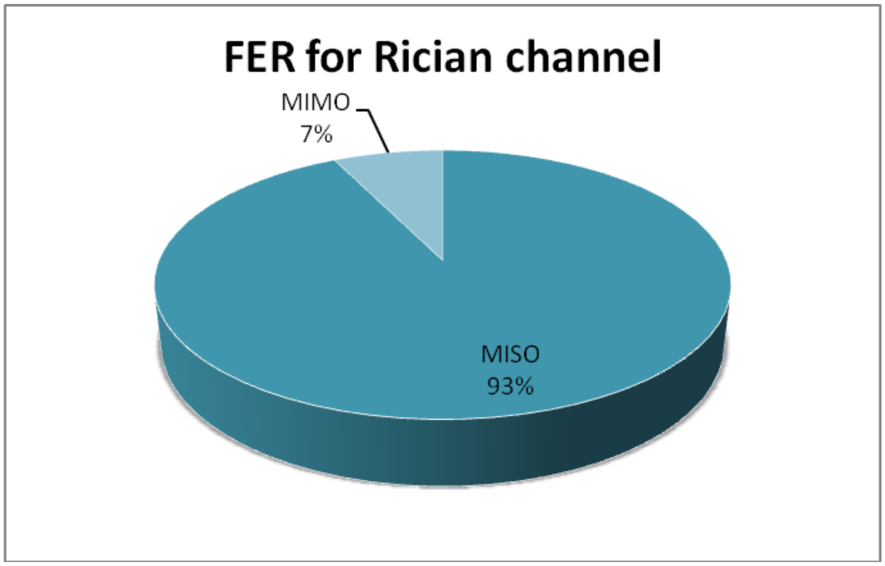

Figure 4.26: Pie chart for FER Alamouti in Rayleigh

Here FER of MIMO (TxR, 2x2) is very lower than MISO (TxR, 2x1) Rayleigh fading channel.

In Rician, this case considered the number of transmit antenna is two and the number of receive antenna is one. Here, the FER is measured only when considered the number of error frame is 1000. QPSK modulation technique is used in this case. The percentage of FER for Alamouti (2x1) is almost 5.54.

In this case considered the number of transmit antenna is two and the number of receive antenna is one. Here, the FER is measured only when considered the number of error frame is 1000. QPSK modulation technique is used in this case. The percentage of FER for Alamouti (2x2) is almost 1.7.

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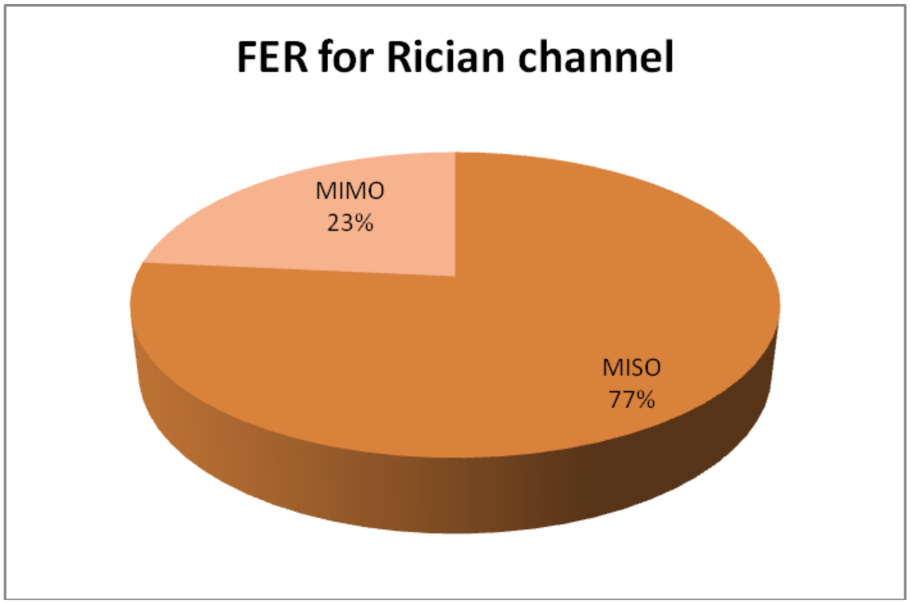

Figure 4.27: Pie chart for FER Alamouti in Rician

Here FER of MIMO (TxR, 2x2) is lower than MISO (TxR, 2x1) Rician fading channel.

4.10 FER calculation for QPSK Alamouti

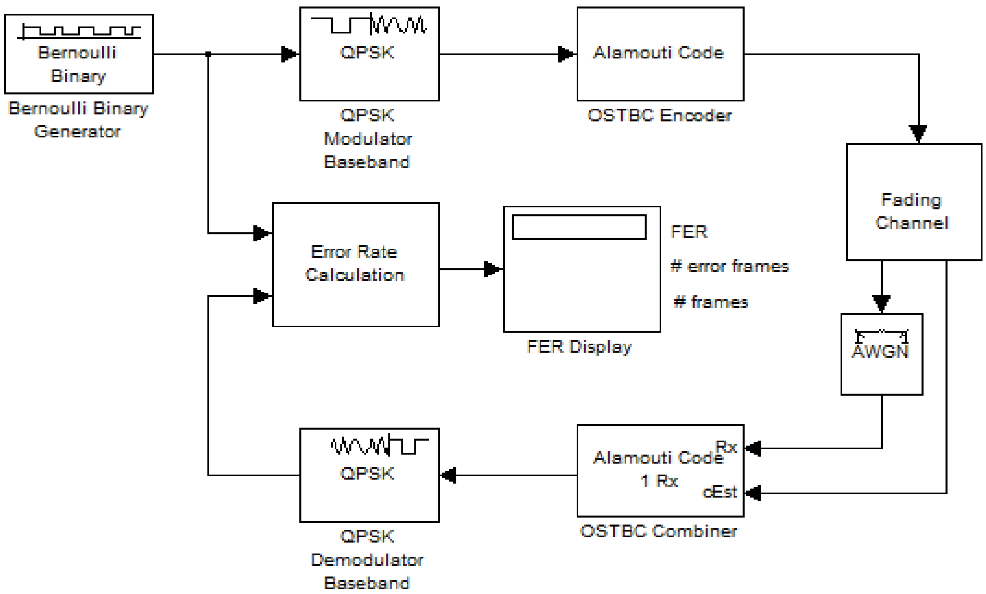

Figure 4.28: Block diagram of FER calculation for QPSK Alamouti.

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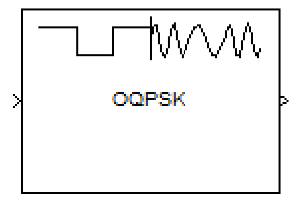
In this diagram there are two new block set. These are QPSK Modulator baseband & QPSK Demodulator baseband. The short definition of these two new block set is given below:

4.10.1 QPSK Modulator and Demodulator Baseband

Quadrature Phase Shift Keying (QPSK) is a form of Phase Shift Keying in which two bits are modulated at once, selecting one of four possible carrier phase shifts (0, 90, 180, or 270 degrees)[18].

The QPSK Modulator Baseband block modulates using the quaternary phase shift keying method. The output is a baseband representation of the modulated signal. QPSK allows the signal to carry twice as much information as ordinary PSK using the same bandwidth. The output is a baseband representation of the modulated signal. If the Input type parameter is set to Integer, then valid input values are 0, 1, 2, and 3. If the input is m, then the output symbol is

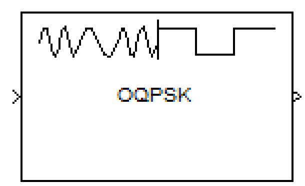
$$\exp(j\theta + j\pi m/2)$$



OQPSK
Modulator
Baseband

Where θ the Phase isoffsetparameter In this case, the input can be either a scalar or a frame-based column vector.

The QPSK Demodulator Baseband block demodulates a signal that was modulated using the quaternary phase shift keying method. The input is a baseband representation of the modulated signal.



OQPSK
Demodulator
Baseband

The input must be a discrete-time complex signal. The input can be either a scalar or a frame-based column vector. If the Output type parameter is set to Integer, then the block maps the point

$$\exp(j\theta + j\pi m/2)$$

Where θ is the Phase offset parameter; m is 0, 1, 2, or 3.

From the simulation the table below was found,

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Modulation Technique	Fading Channel	No. of (Tx)	No. of (Rx)	Antenn a types	Number of error frames	No. of Frames	FER	Approxi-mate (%) of FER
QPSK	Rayleigh	2	1	MISO	1000	3495	0.2861	28.61
		2	2	MIMO	1000	7213	0.1386	13.86
	Rician	2	1	MISO	1000	2952	0.3388	33.90
		2	2	MIMO	1000	5042	0.1983	19.83

Table 4.3 : FER Calculation in Multipath fading channel.

In Rayleigh, this case considered the number of transmit antenna is two and the number of receive antenna is one. Here, the FER is measured only when considered the number of error frame is 1000. QPSK modulation technique is used in this case. The percentage of FER for Alamouti (2x1) is almost 28.5.

In this case considered the number of transmit antenna is two and the number of receive antenna is one. Here, the FER is measured only when considered the number of error frame is 1000. QPSK modulation technique is used in this case. The percentage of FER for Alamouti (2x2) is almost 13.86.

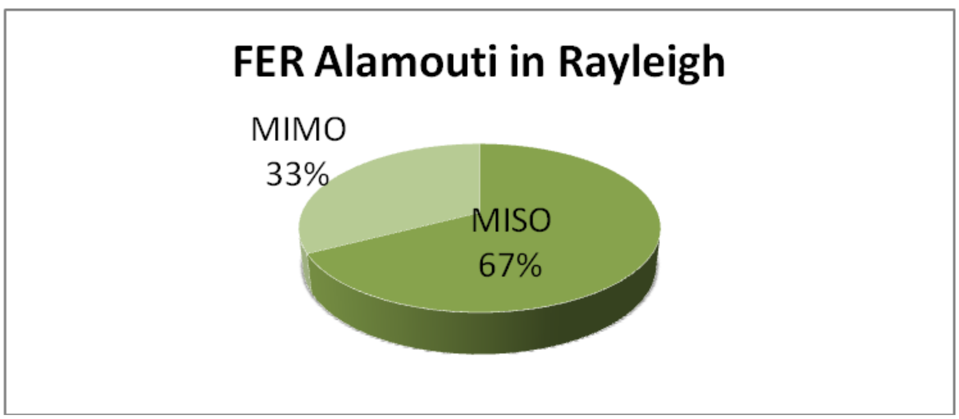

Figure: 4.29: Pie chart for FER Alamouti in Rayleigh.

Here FER of MIMO (TxR, 2x2) is lower than MISO (TxR, 2x1) in Rayleigh channel.

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In Rician, this case considered the number of transmit antenna is two and the number of receive antenna is one. Here, the FER is measured only when considered the number of error frame is 1000. QPSK modulation technique is used in this case. The percentage of FER for Alamouti (2x1) is almost 34.

In this case considered the number of transmit antenna is two and the number of receive antenna is one. Here, the FER is measured only when considered the number of error frame is 1000. QPSK modulation technique is used in this case. The percentage of FER for Alamouti (2x2) is almost 20.

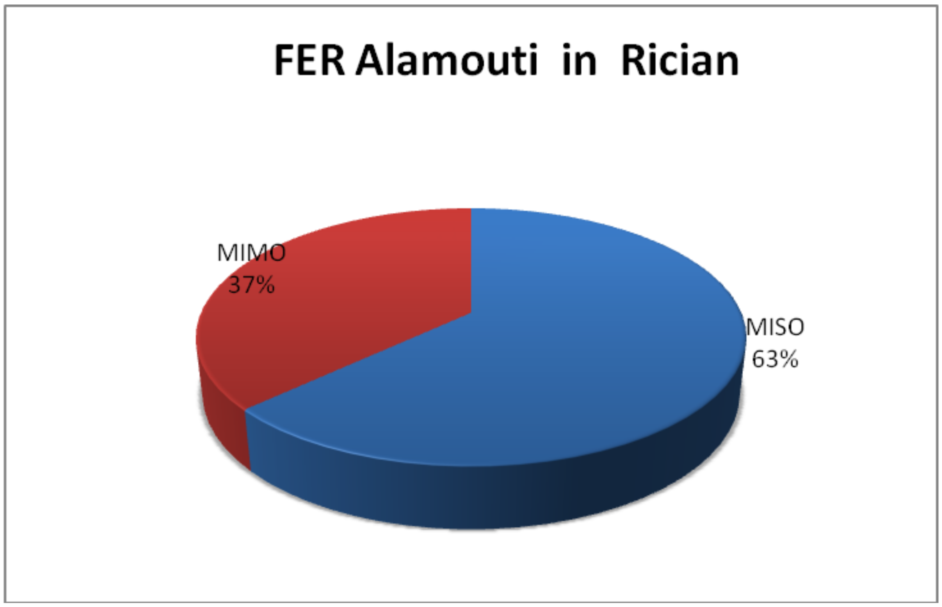

Figure: 4.30: Pie chart for FER Alamouti in Rician.

Here FER of MIMO (TxR, 2x2) is lower than MISO (TxR, 2x1) in Rician channel.

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4.11 Advantages

Due to the targeted nature of smart antennas frequencies can be reused allowing an increased number of users. More users on the same frequency space means that the network provider has lower operating costs in terms of purchasing frequency space.

As the smart antenna focuses gain on the communicating device, the range of operation increases. This allows the area serviced by a smart antenna to increase. This can provide a cost saving to network providers as they will not require as many antennas/base stations to provide coverage.

As smart antennas use 'targeted' signals the direction in which the antenna is transmitting and the gain required to communicate with a device can be used to determine the location of a device relatively accurately. This allows network providers to offer new services to devices. Some services include, guiding emergency services to your location, location based games and locality information.

Smart antennas naturally provide increased security, as the signals are not radiated in all directions as in a traditional Omni-directional antenna. This means that if someone wished to intercept transmissions they would need to be at the same location or between the two communicating devices.

Interference which is usually caused by transmissions which radiate in all directions are less likely to occur due to the directionality introduced by the smart antenna. This aids both the ability to reuse frequencies and achieve greater range.

The bandwidth available increases form the reuse of frequencies and also in adaptive arrays as they can utilize the many paths which a signal may follow to reach a device.

Smart antennas are not a new protocol or standard so the antennas can be easily implemented with existing non smart antennas and devices.

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4.12 Problems

A disadvantage of smart antennas is that they are far more complicated than traditional antennas. This means that faults or problems may be harder to diagnose and more likely to occur.

As smart antennas are extremely complex, utilizing the latest in processing technology they are far more expensive than traditional antennas. However this cost must be weighed against the cost of frequency space.

Due to the antenna arrays which are utilized by smart antenna systems, they are much larger in size than traditional systems. This can be a problem in a social context as antennas can be seen as ugly or unsightly.

The location of smart antennas needs to be considered for optimal operation. Due to the directional beam that 'swings' from smart antenna locations which are optimal for a traditional antenna is not for a smart antenna. For example in a road context, smart antennas are better situated away from the road, unlike normal antennas which are best situated along the road.

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CONCLUSION

5.1 Future Work

The smart antenna system can be expanded in many other ways. The theory of the output of the smart antenna system could be done in practical investigated. And we analysis only on reception of signals but it can also be done at transmission vice versa and also then analysis combining two together.

5.2 Conclusion

This paper has analyzed the performance of Different types of smart antenna systems in terms of SNR, BER & FER in Rayleigh fading &Rician fading channel. At first it has been analyzed for the various numbers of antennas. For SIMO case, T=1 & R=4 is given better performance than T=1 & R=2. This is happened for the case of MISO & MIMO case also. At last the performance analysis between all of them with same value of SNR, it is shown that MIMO outforms SISO, SIMO & MISO.

BER performance scheme has been verified for MISO & MIMO in Rayleigh Fading channel and Rician Fading channel. In this case BPSK & QPSK modulation technique is used. In Rayleigh channel The BER of MISO(TxR=3x1) is almost 6.1% & for MIMO(TxR=3x3) is almost .4% again MISO(TxR=4x1) is almost 10.3% & for MIMO(TxR=3x2) is almost 5.1%.

For Rician fading channel the BER of MISO(TxR=3x1) system is increased & it is almost 7.7% but for MIMO(TxR=3x3) system the value of BER is decreased & it is about 2.4%. Whereas the BER of MISO(TxR=4x1) system is increased & it is almost 3.8% but for MIMO(TxR=4x2) system the value of BER is increased & it is about 9.6%.

For alamouti code (2x1 & 2x2) the FER is also measured. The FER of alamouti 2x2 is much lower than the alamouti 2x1 in both case of MPSK and QPSK modulation scheme (for both Rayleigh fading channel &Rician fading channel). So the alamouti 2x2 can support highest data rate than alamouti 2x1 systems.

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