Enhancing Mobile Network Performance using Multiple in-Multiple out Antenna Diversity

Abstract

Wireless communication services have been growing at a rapid pace in recent years. As the number of mobile communication users' increase, the demand for a more reliable mobile network also increases. Therefore, there is an important need for overall improvement in mobile network performance using Multiple In-Multiple Out (MIMO) antenna diversity technique to mitigate the gross effect of signal loss. The field data measurement from a transmitting base station was collected using data analytics tools such as spectrum analyser, network planning tools and global positioning system (GPS) gadgets. The distances of the measurement points from the transmitting base station was recorded using GPS, while the received signal strength and signal-to-noise-ratio (SNR) calculation was done with the spectrum analyser and network planning tool. In this project, the received signal strength of SISO, SIMO, and MISO base station antenna systems were obtained from the simulation result of the field data; this showed high signal loss, while the result obtained using MIMO 4 x 4 antenna diversity resulted in 200% high signal gain and increased network coverage.

Keywords: MIMO, SIMO, GPS, Antenna

Introduction

Wireless communication involves the transmission of information over a place minus assistance from another type of electric conductors, or cables. The transmitted space might be ranging from several meters at the eventuality of a television's remote controller plus tens and thousands of kilometres for wireless communication. Wireless communication has gained popularity thanks to improved antenna technologies, lower costs, quicker installation of wireless technologies, better efficacy, better reliability and also the demand for communication. They are normally implemented and handled with a transmission system called waves.

Depending on the elegance of this system, the signals might be used directly (equal gain blending) or discretionary and extra coherently (maximal-ratio mixing). This kind of method gives the ideal resistance to fading but as most of the receive avenues needs to remain energized; in addition, it consumes the most energy. In just about all applications yet the diversity decisions are created by the recipient and are not known to the transmitter. Reflection occurs if the waves impinge on items that are much larger compared to the wavelength of this travelling wave. Diffraction occurs if the wave interacts with a face together with sharp flaws (boundaries). Scattering occurs if the medium by which the tide is flying comprises objects that are significantly more compact compared to the wavelength of the triangular wave.

All these propagation effects make multi-path of this transmitted signal. At the recipient, the quite a few duplicates of this input in a variety of paths. Strong destructive disturbance can be known as a profound fade and can cause temporary breakdown of communicating because of critical drop from the station signal-to-noise-ratio. The principal goal in electronic communication will be always to create a high-quality communication system. This calls for making a greater bitrate as well as good error operation. It provides a few inputs from the recipient like the evaporating happenings among those inputs are uncorrelated. In case one radio course experiences a profound fade in a certain point in time, then it's very likely that yet another individual (or highly uncorrelated) course has a decent signal. Multiple input - multiple - output (MIMO) antenna diversity techniques are all also known to do the job in resisting station handicap arising due to multipath fading. This may be accomplished in many ways based on the ecosystem and also the expected disturbance (spatial diversity – horizontal or vertical, pattern diversity, and polarization diversity, etc.). These processes are traditionally utilized to enhance signal calibre. Multiple-antenna methods deliver high transmission rates over fading channels and also aid in raising the diversity sequence of signals over slow fading channels. Schemes employing diversity decisions making at the unknown and transmitter to the receiver are infrequently practiced.

Mobile radio channel puts fundamental limit about the performance of wireless communication platform. That is a result of the simple fact that the wireless spectrum available for wireless users will be exceptionally infrequent, as the requirement of these solutions is growing in a fast pace. The fundamental happenings which produces transmission undependable is time varying fading (Mark & Zhuang, 2007) that excite as a result of potential presence of multiple paths from the transmitter to the recipient using destructive combination from the receiver output. These propagation effects make multi-path of this transmitted signal. From the recipient, the various copies of this input signal in various paths. Each of those signals might possibly experience difference in period shift, timing delays, attenuation and distortion which may wreak havoc with one another in the aperture of the antenna. Strong harmful disturbance can be called a profound trickle and might lead to temporary failure of communicating because of critical drop within the channel signal-to-noise-ratio. Substantial attenuation of wireless channel results in rather poor performance, even short periods of profound fade cause big performance penalty. Other challenges experienced with all our current day 2G/3G/4G networks are:

1. Challenges of multipath propagation experienced from base transmitter channels to mobile phones that hamper network signal
2. Challenges experienced with signal range, coverage, and speed in certain urban areas (as for signal range and rate) and rural areas (like network protection)

In wireless communications, MIMO antenna diversity is more effective in simplifying multipath situations since multiple antennas provide you with the receiver a few observations of the identical signal and each antenna experiences yet another disturbance atmosphere. The fundamental notion of using MIMO antenna motto is that in case one antenna is still undergoing a profound incline, it's quite probable that somebody comes with a decent signal and also the full system can furnish a robust-link additionally lessen the range of both drop outs and overlooking connections.

The main goal of this research is to improve signal reception by mitigating the impact of multipath in wireless communication channel with MIMO antenna diversity and MIMO technique. Specifically, this work also seeks the following:

1. To examine the variation of signal reduction on the distinguished environment so as to get the effects of MIMO antenna diversity in enhancing signal reception on wireless network.
2. To examine the quality of service (QoS) parameters such as range, coverage and speed.

3. To demonstrate how 4 X 4 MIMO antenna diversity technique can boost all parameters concurrently.

This work concentrates on Improving signal reception in wireless communication network using MIMO antenna diversity techniques. Real time measurement was completed in Okigwe-Ihube rural region, Enugu urban area in South-East Nigeria with MTN Nigeria network infrastructure. The area data of signal power concerning the space of mobile users from BS was obtained. The signal strength measured was used in the evaluation of path loss model described for a typical Wireless Code Division Multiple Access network. The projected path loss exponent of the test bed environment was used in characterizing the propagation environment. Also, the work explored Transmit and Receive diversity technique which reduces degradation in link functionality. This assesses the usage of transmit diversity schemes to preserve deadlines and mitigate multipath fading in a wireless channel. Channel version is considered as Rayleigh fading and antenna sound as Additive White Gaussian Noise (AWGN). The simulations are done in Matlab environment.

Strong harmful disturbance can cause profound fade and might lead to temporary failure of communicating as a consequence of intense drop from the station signal to noise ratio. To overcome this matter, a MIMO antenna diversity procedure is suggested. This research aids the mobile system operators handle industry requirements for quality and efficacy without a complete redesign of the system. It will also function as a recommendation for researchers on the very ideal way to increase signal reception in wireless communication strategy utilizing multiple antenna methods. Furthermore, the employment of transmit diversity plan has been made more persuasive from ongoing reduction in the cost of electronic signal processing hardware, so that the more developments out of the signal blending processing together with the above system benefit. Continuous fascination with this topic has yielded a brand-new analytical effect (Sik-Ali, Cardinal & Gagnon, 2010); ergo to receive yourself a system with N users at a horizontal Rayleigh environment, signal mixing supplied by way of a base channel with K+N antennas can churn out N L interference and reach K+civic diversity advancement contrary to multipath fading. The main contribution of this research is the fact that the generalization and distribution of useful expansion of this method to make use of transmit diversity plan to distance diversity methods. Specifically, an expression for the error execution with the brand-new strategy with coherent binary phase shift keying (BPSK) modulation is introduced and can be contrasted to maximum-ration-combining (MRC). This tactic provides some sort of transmission diversity for signal broadcasts; the idea will be to equip an essential channel with lots (K) of all spatially separated antennas whereby a wireless station can receive with one antenna. This analysis work also gives a method to calculate the path loss exponent which is critical to describe the signal propagation ecosystem.

1. Literature Review

There are lots of diversity techniques which could possibly be implemented to communicating techniques; we cite herein time diversity, frequency diversity, and cognitive diversity or some other mix of these 3 diversities. In a communication system, we need to enhance the dependability of this communicating performance between transmitter and receiver whilst keeping a high spectral efficiency; that is accomplished with diversity (Mohaisen, Wang & Chang, 2010). Diversity methods can exploit the multipath propagation, resulting in a diversity advantage, frequently measured in decibels. MIMO antenna diversity is especially effective at ridding these multipath circumstances. That is only because multiple antennas provide the recipient several discoveries of the specific same signal.

Additionally, with the several signals there exists a greater processing requirement determined by the recipient, which might cause smaller design demands. On average, however, signal reliability is overriding and with many antennas is a more powerful way to reduce the number of drop outs and overlooking links. Antenna diversity might also be accomplished in a range of means. Predicated on the surroundings and also the expected disturbance, the designers may employ a minimum of among the solutions to increase signal quality (Mietzner, Lampe & Gerstacker, 2009). Included in these are vertical, routine, polarization, elastic arrays along with also transmit/receive diversity. To increase reliability, multiple approaches are utilized in reality. Since wireless systems have been susceptible to evaporating, that can be recognized to trigger degradation in connection performance, evaporating mitigation strategy is demanded. All the aforementioned methods need some form of article processing to recoup the message, these methods are changing, picking, mixing and playful controls. Diversity mixing is an extremely effective technique that might possibly be utilised to fight evaporating in wireless technologies contributing to improving connection functionality. Diversity mixing is the system applied to combine the multiple received signals of a diversity reception device to one enhanced signal. Various diversity blending methods exist like selection blending, varied blending, equal gain combining and maximal-ratio blending. On occasion, several blending procedures is utilized to boost operation. Antenna arrays using maximal-ratio Combining can greatly combat both multipath fading of their desirable signal, and then increasing the operation of wireless radio communication procedures. In blending, all antennas maintain base connections constantly. With antenna arrays, also called elastic arrays, significant performance improvements may be had despite a few of antenna elements, thereby increasing the odds of elastic arrays for always a low-cost solution to alternative ways of increasing capacity, like reducing the cell size (Mark & Zhuang, 2003).

2. Experimental Design

3.1 Measurement Environment/ Experimental Test-Bed

The study is carried out at Okigwe-Ihube Region and Enugu region in South-East Nigeria. The area data dimensions were obtained from the base stations located in Enugu town and hand-over base channels across Okigwe-Ihube state manner. The evaluation environments comprise Base channels at Coal Camp, Okpara Avenue, State Secretariat, Ebeano Tunnel and Bisalla Road.

3.2 Measurement Apparatus/ Instrument for Data Set

The devices include Spectrum analyzer, Global Positioning System (GPS); the received signal strength (RSS) was quantified with the support of ray-tracer applications installed from the spectrum analyzer gear. The elevations, coordinates and distances in the transmitting base stations and also the dimension points were recorded with the support of global positioning system (GPS). The gear specifications are as follows:

• **Base Station Specification:**

Frequency Array: GSM 900-GSM 1800MHz

Antenna Height: 30m

Transmitting Electricity: 40dBm

Antenna Sort: Sectorized (Traditional antenna system)

Antenna Profit: 16dBi

• **Spectrum Analyzer:**

Type: Bench Top

Model: AT5011

Frequency Range: 0.15-1050MHz

3.3 Data Collection Procedure

The measurement setup is shown in Fig. 3.2. The spectrum analyzer was used to quantify the received signal power level (power obtained) in a distance (d) In the base channel. The ray-tracer software set up the spectrum analyzer includes of a scale, which signify the energy received in dBm. For Each cell from the surroundings researched, power received in a distance 100 meters from the base channel was quantified.

The Global positioning system GPS was used to find out the geographical coordinate and space. Figure 3.1 shows the MTN base channel at which the field evaluation was completed for five times between 10am to 3pm in Enugu metropolitan region in South-East Nigeria and five BS mobile sites chosen from the areas of analysis.

The received signal power were measured and examined with the assistance of applications embedded and installed in the spectrum analyzer. Averaging is performed to compensate for variation in signal Strength at a specific place over time.

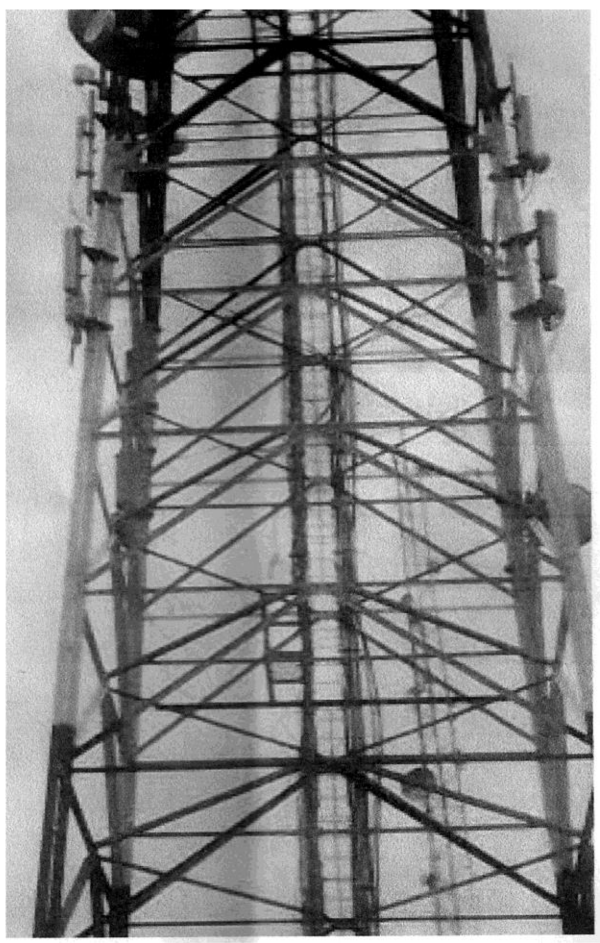


Fig. 3.1: Experimental Testbed.

Source: Field work photography of MTN Nigeria Base Station

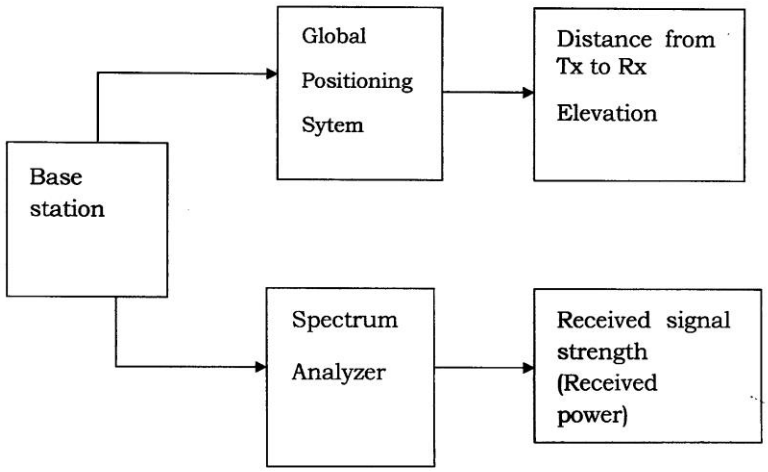


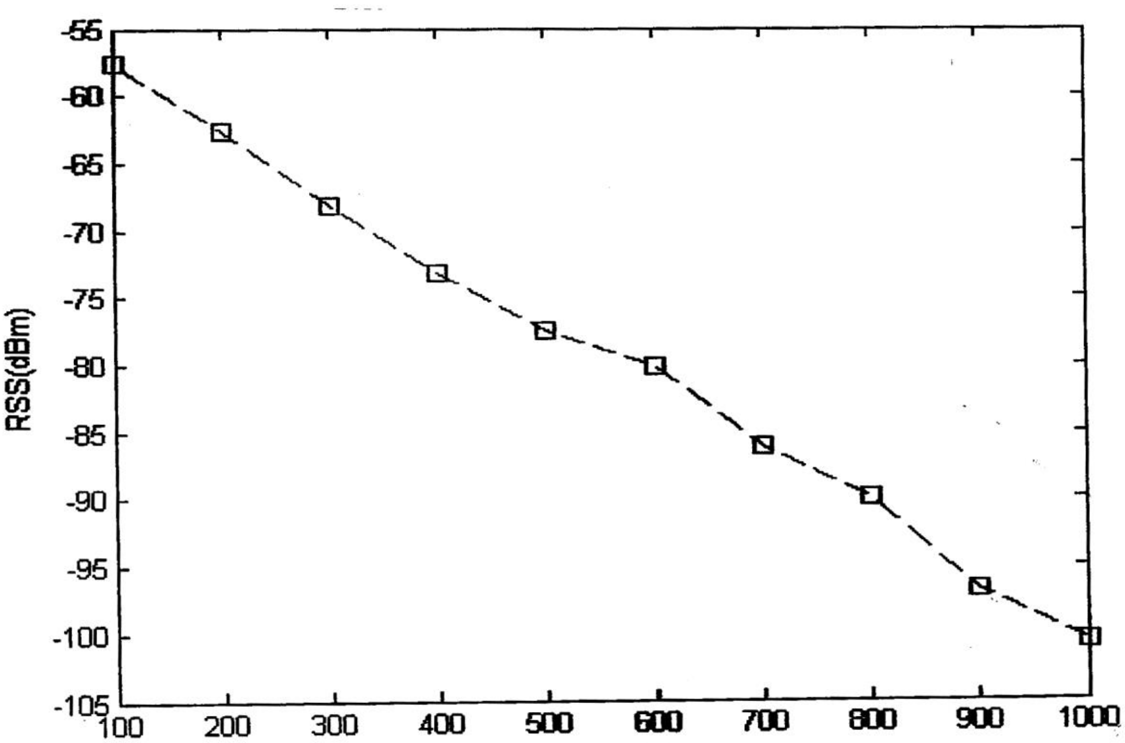
Figure 3.2 Schematic Diagram of the Test Setup

3. Simulation Results & Data Analysis

4.1 Path Loss (Signal Loss) Exponent Analysis

From the figure 4.1, it is obvious that as the distance increases the received signal decreases. The path loss exponent, n, of the test bed area is 3.7 as obtained from the measured data. The developed model from the field data can be used in predicting RSS.

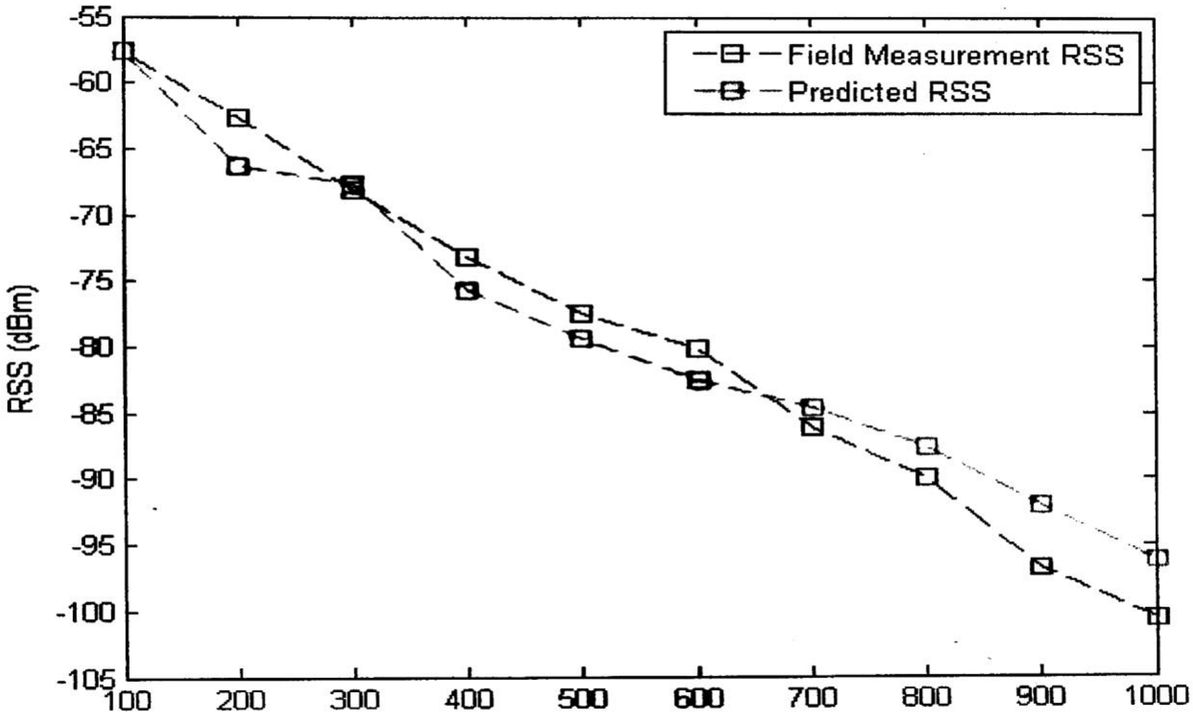
Distance VS Field Measurement of RSS



Distance (m) vs Field Measurement of RSS

Figure 4.1 Received Signal Strength (RSS) *vs* Distance for the characterized environment (i.e experimental testbed)

Comparison of field Measurement RSS and Predicted RSS during simulation



Distance (m) vs Field Measurement of RSS

Figure 4.2 Measured and Predicted RSS vs Distance

Figure 4.2 shows the line of best fit that exist between the two graphs, there is a good agreement between the Field RSS and Predicted RSS.

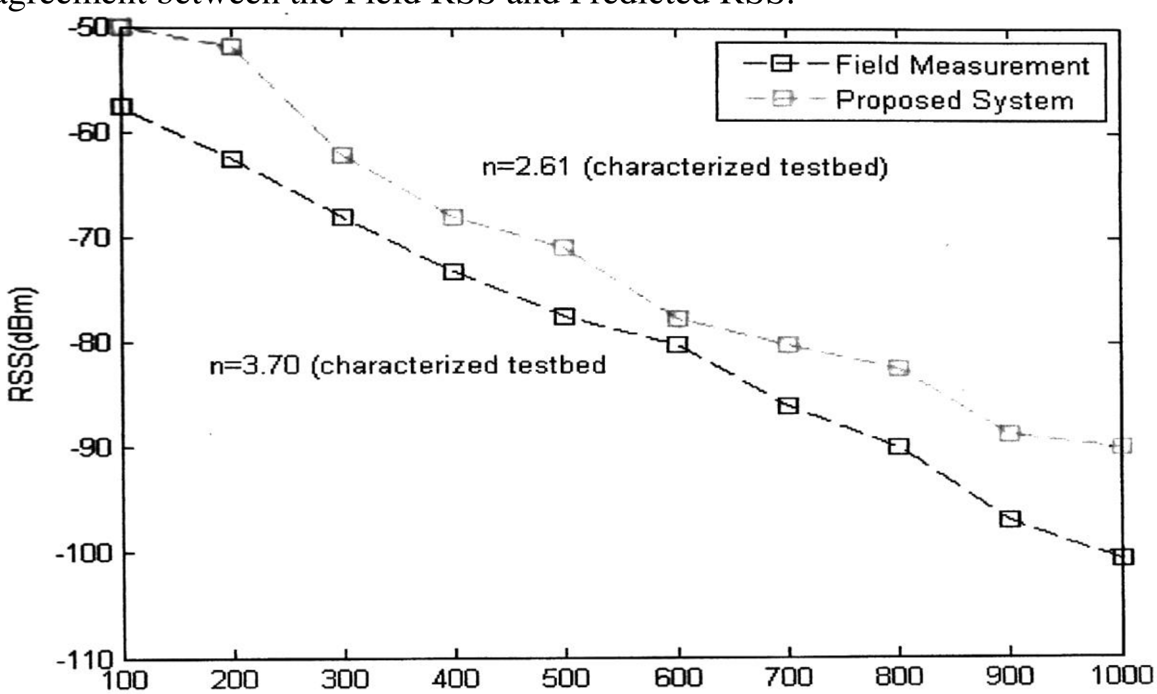


Figure 4.3: RSS (Field) and RSS (MIMO Antenna Diversity) *Vs* Distance

Figure 4.3 shows the diversity antenna method in improving performance of their Wideband code division multiple access(WCDMA) system by decreasing multipath fading and multiple access interference. A progress is on their WCDMA network operation. The path loss exponent of all 2.61 acquired using antenna system similar to that of 3.70 acquired by the distinguished test bed environment. The pace at which indicate dropped is minimum once MIMO antenna diversity is utilized on the system when compared with large signal loss experienced if not utilized on the system. Figure 4.4 shows the Bit Error Rate (BER) Performance of Two-branch Transmit with a single Receiver.

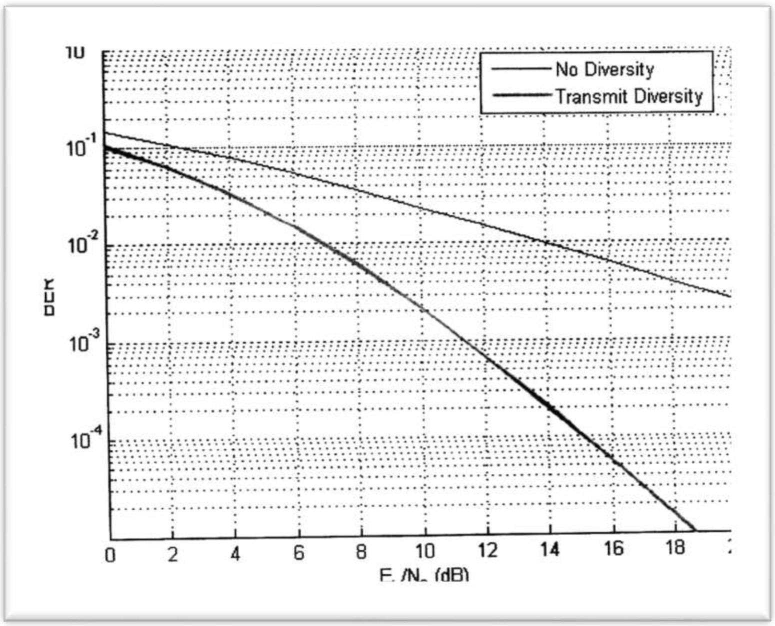


Fig. 4.4: The BER performance of coherent BPSK using two-branch transmit diversity with a single recipient (MISO) at Rayleigh fading.

Fig. 4.4 shows the functionality of the transmit diversity strategy with two transmitters plus one receiver antenna strategy. In the diagram, in BER of 10~4the transmit diversity 15dB and no diversity is OdB as a result, the functioning of the station with transmit diversity plot of 2 transmitters and one receiver antenna plot is roughly 15 dB greater than the no diversity station. The 15-dB advantage is attained because the signal is transmitted over many channels which undergo independent fading and coherently mixing them from the receiver, and thus conquer degradation in the link performance. This performance is also possible because the simulations assume that each transmit antenna frees complete energy to have the ability to be sure the specific same total radiated power substantially enjoy no diversity variation. Additionally, it is assumed that the amplitudes of evaporating from each transmit antenna to the receiver antenna are uncorrelated Rayleigh distributed along with also the typical sign forces in the receive antenna from each transmit antenna are the same. It's obviously seen that the operation of no diversity (SISO system) at a fading channel is quite bad in comparison to multiple antennas in the transmitting side.

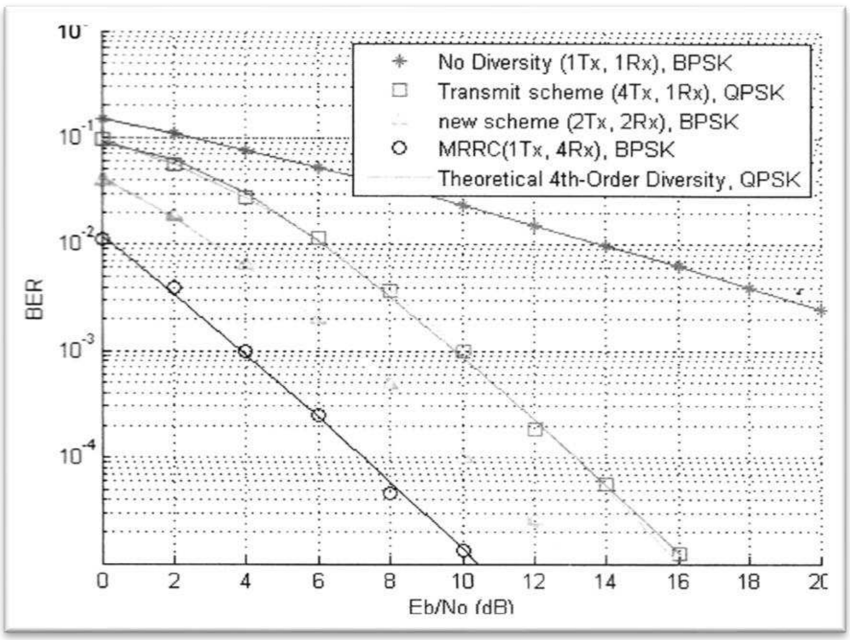


Fig. 4.6: The BER performance of contrast coherent BPSK with MRRC and Transmit Style in Rayleigh fading.

Fig.4.6 shows the BER Functionality of coherent BPSK with MRRC and two-branch transmit diversity with two receivers from Rayleigh fading. The transmit diversity approach with two transmitters and two receiver antennas attained greater equal performance benefit with all the two-branch MRRC. This very indistinguishable performance implies equivalent energy by every transmit antenna at either transmitters and two receivers strategy because the only transmit antenna for MRRC. This agrees with the assumption that the performance curves for two transmitters and a single receiver storyline could alter 3 dB to the left and prevailed together with the MRRC curves Once the BER was attracted out of the typical SNR per transmit antenna as stated curves are cite examples. The essential observation is that transmit diversity approach together with two transmitters and two receiver antennas provides similar performance to MRRC, no matter the used coding and modulation schemes. The results from these books can be used to predict the functioning of transmit diversity approach utilizing modulation procedures.

Table 4.2: Received signal strength (RSS) from Convectional antenna and RSS using MIMO antenna diversity technique.

Distance	RSS(dBm): Convectional Antenna	RSS(dBm): MIMO antenna diversity
100	-57. 63	-57.63
200	-62.57	-66.28
300	-68.06	-67.70
400	-73.17	-75.64
500	-77.49	-79.37
600	-80.16	-82.58
700	-86.02	-84.66
800	-89.98	-87.50
900	-96.83	-91.96
1000	-100.65	-96.18

The table 4.2 is a clear comparison of the existing average signal and the proposed MIMO antenna diversity technique. Despite the increase in distance, there is an appreciable stability and throughput in received signal strength.

For SISO system using Rayleigh Fading Channel

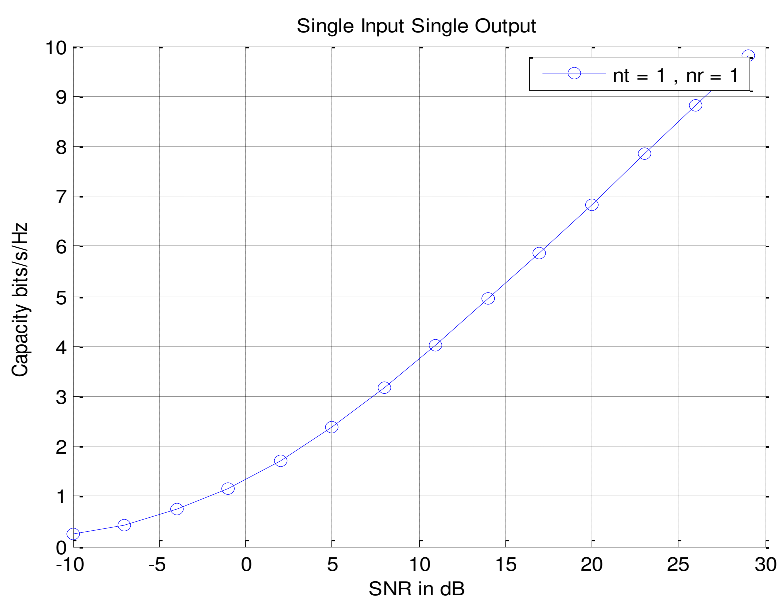


Figure 4.7. Simulation result of SISO

For MIMO system using Rayleigh fading channel

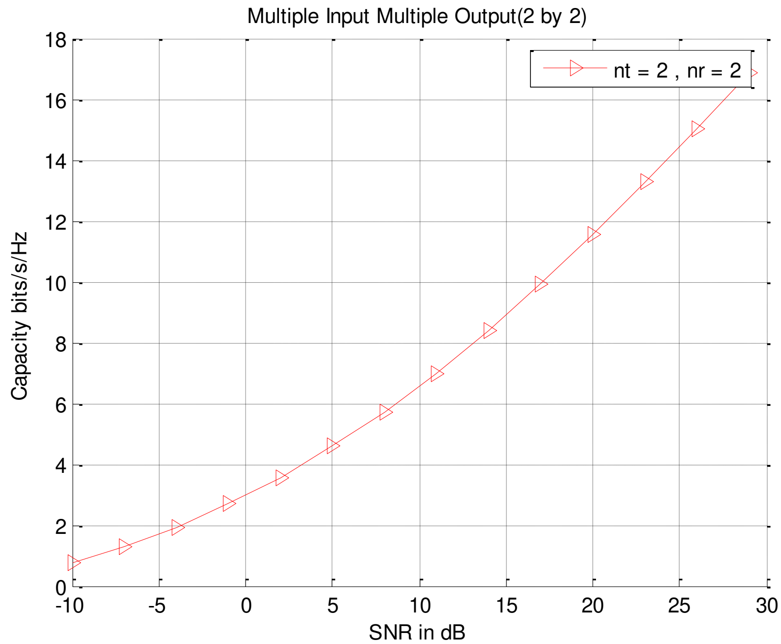


Figure 4.8. Simulation result of MIMO

Comparing the two systems, (MIMO, SISO) it is seen that capacity of the channel was increased when adding an additional antenna on both the transmitter and the receiver as in the above graph.

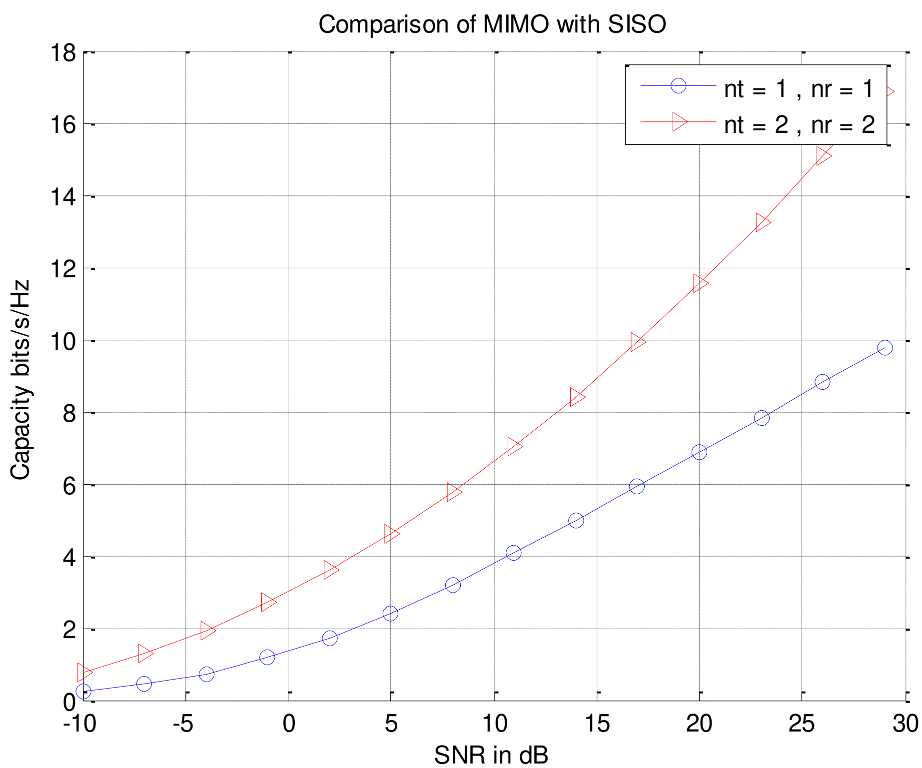


Figure 4.9. Comparison of MIMO using SISO

The aforementioned has shown that this MIMO multiple-antenna techniques may considerably enhance the performance of wireless transmission systems by given choice into the Staff Wireless Communication. Systems are trending towards using multiple antennas at the BS and possible systems are evolving to several antenna systems at the SS. More advanced MIMO techniques can improve performance well beyond the current limits of information rate and reach. Virtually their exist approach (communication devices) that are layout on SISO basic, which promote the question what will be the channel capacity if you are able to discover unbalance assortment of radios side? With this floor a strategy is employed in simulation of the channel capability system.

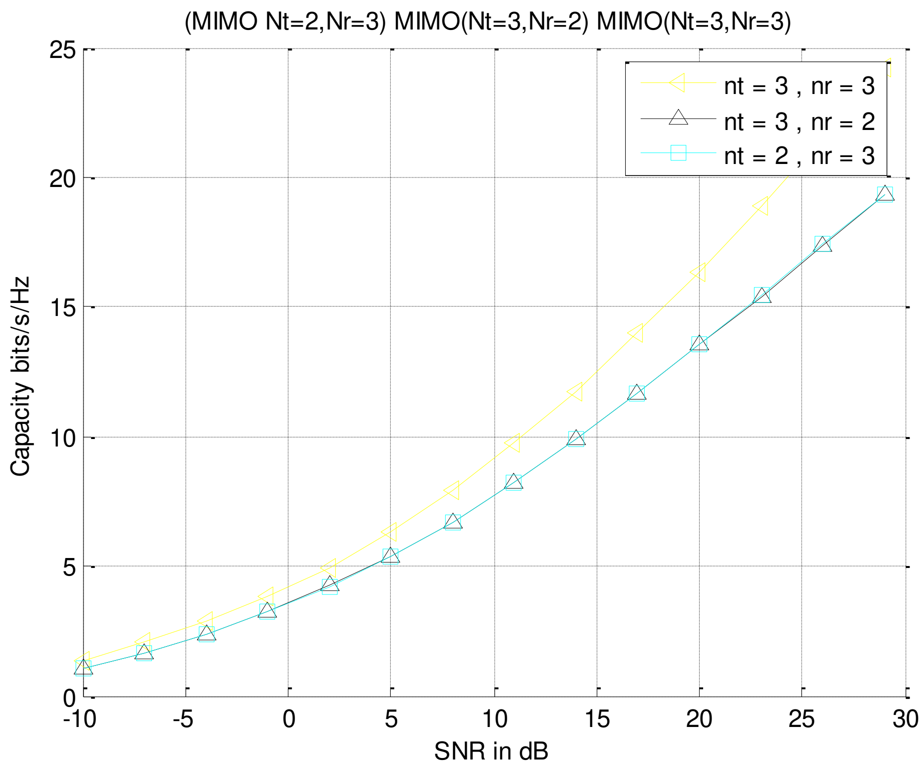


Figure 4.10. Simulation result of MIMO,MISO,SIMO

As seen in the above graph in a Rayleigh fading channel the capacity grows linearly with min (N_t,N_r) this imply that channel capacity of a wireless communication is most influenced by the minimum number of antenna in neither the transmitter side or the receiver side.

4.5 Results and Implications

Thus far, the outcome of the simulation and mathematical analysis have shown that the transmit diversity strategy using two fold and M receive antennas (MISO) is equal to MRRC with a single transmit antenna and 2M get antennas (SIMO) Quite simply, they both possess exactly the same diversity order for M.

Conclusion and Recommendations

It is obviously seen that by tapping on antenna Diversity and adopting MIMO techniques, it is possible to effectively mitigate the outcome of signal loss and multipath fading. In using MIMO antenna diversity, heavy channel fades are absent along with restricted quantity of transmitted electricity is enough to compensate for fading. Compared with antenna system, it enhances the signal's error performance. This simulation has revealed that multiple-antenna techniques (MIMO) can significantly enhance the operation of wireless transmission procedures. Systems are currently geared towards using multiple antennas at the BS and prospective applications may evolve to multiple antenna systems at the SS. This project has provided evidence the MIMO procedure is the way of attaining the substantial claims of 4th and 5th Production communication. More MIMO methods can boost functionality well and attain.

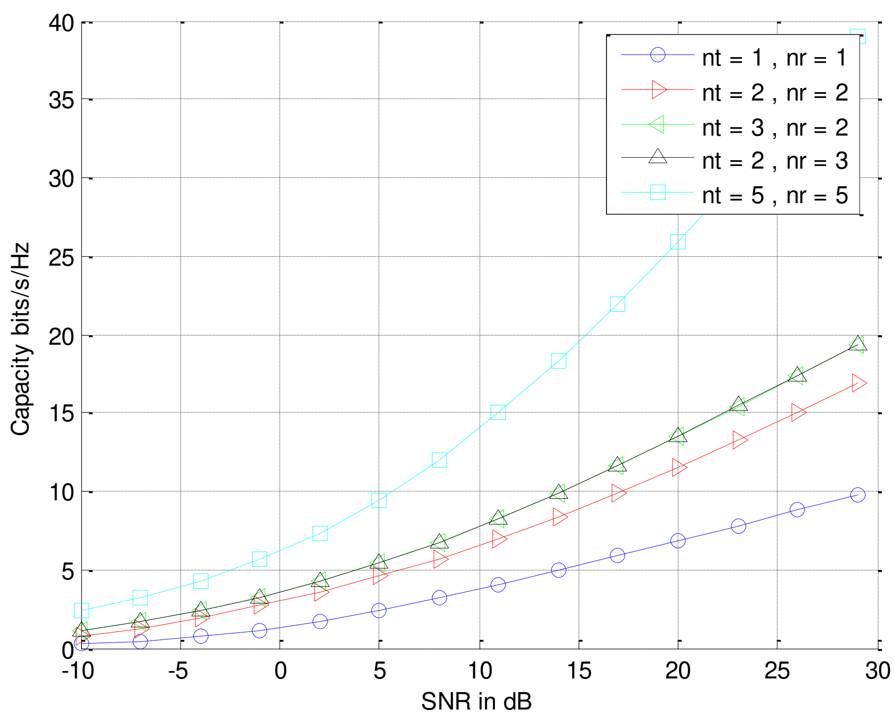


Figure 5.1. Simulation result of Multiple Antenna MIMO Technique
Source: MATLAB Network Simulation Environment

In the above-mentioned result graph in figure 5.1 that demonstrates that MIMO is the key to a superior cellular network operation. Furthermore, it's been shown that, together with two transmit antennas and one receive antenna, provides the specific same diversity order as MRRC using one transmit and 2 receive antennas. An obvious application of the scheme is to provide elegance progress in any method of these remote components in a wireless network, using two transmit antennas from the base channels rather than two receive antennas in each of the remote terminals. The plan does not involve any comments from the receiver to the transmitter and its computation complexity is quite like MRRC. Furthermore, it provides the no-diversity link (single transmit- receive antenna case) and theoretical performance of second-order diversity link for comparison. It is assumed here that the channel is known perfectly at the receiver for several systems. We run the simulation over a choice of Eb/No aspects to make BER outcomes that empower us to compare various systems. It is observed that in case the amount of receiving antennas has increased the performance of system is increasing i.e. the error probability of program declines. As compared with MRRC, if the entire Radiated power would be to remain exactly the same, the transmit diversity approach has a 3-dB less because of the simultaneous transmission of two distinct symbols from two antennas. Otherwise, if the total radiated energy has been lost, then its performance is equivalent to MRRC. Additionally, assuming equivalent radiated power, the plan requires two half-power amplifiers in comparison to a complete energy amplifier for MRRC, which could be advantageous for system implementation.

5.2 Recommendations

This work makes recommendations based on the present findings from the mobile telecommunication sector that requires urgent care for far better advancement as well as the advantages of this MIMO 4 x 4 Fragrant diversity technique that ought to be implemented to make sure that issue of signal reduction is removed. Considering that MIMO antenna diversity technique is known to reduce error speed, spatial multiplexing increases data speed and beam forming enhances signal-to-interference-noise ratio. Thus, mobile network Operators must unite MIMO 4 x 4 antenna diversity technique with spatial multiplexing and beam forming to boost overall network operation.

References

Alamouti (1998). *A Simple Transmit Diversity Technique for Wireless Communications.* IEEE Journal on Select Areas in Communications, Vol.16, No. 8, pp. 1451-1458, October 1998.

Bharti and Gupta (2011). *Improving Reception in Wireless Mobile Communication Using MIMO Approach over Rayleigh Fading Channels.*

Heiskala and Terry (2002). *OFDM Wireless LANs: A Theoretical and Practical Guide.*

Li, Vorobyov, Sergiy and Gershman (2009). *Transmit Antenna Selection Based Strategies in MISO Communication Systems with Low-Rate Channel State Feedback.* IEEE Transactions on Wireless Communications, vol. 8, no. 4, pp. 1660-1666, April 2009.

Loyka (2001). *Channel Capacity of MIMO Architecture Using the Exponential Correlation Matrix.* IEEE Communication Letters, v.5, N. 9, pp. 369 – 371, Sep 2001.

Mark and Zhuang (2007). *Wireless Communication & Networks*. Prentice-Hall pp. 123 – 127.

Mietzner, Lutz, Gerstacker, Wolfgang and Hoeher (2009). *Multiple Antenna Techniques for Wireless Communications* – A Comprehensive Literature Survey. IEEE Comm. Survey & tutorials, Vol.11, No.2 second quarter 2009.

Sengupta, Mitra (2001). *Capacity of multivariate channels with multiplicative noise: I. Random matrix techniques and large-N expansions for full transfer matrices.* Bell Labs., Tech. Rep.

Yang, and Kaltenberger (2005). *MIMO Algorithms for Wireless LAN.* Proceedings Wireless Congress, Munich, Germany, October 2005.