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RESEARCH ARTICLE

Enhancing Signal Reception in Wireless Communication Systems using Antenna Diversity

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ABSTRACT

Wireless communication services have been growing at a rapid pace in recent years. As the number of network users increases, the demand for reliable signal reception also increases. So, there is an increasing need for efficient link performance. Therefore, antenna diversity is very efficient in mitigating the effect of multi-path fading. The field data measurement of received signal strength from a transmitting base station which was collected using spectrum analyzer of Model AT5011. The distances of the measurement points from the transmitting base station was recorded using the global positioning system. Also, in this research work the received signal strength using two antenna systems were obtained from simulation. Result obtained from the field data showed that the path loss exponent of the characterized environment was 3.70 while the result obtained using antenna diversity resulted in path loss exponent of 2.61. Also this research work presents a two-branch transmit diversity scheme using two transmit antennas and one receive antenna. It is also shown that the scheme may easily be generalized to two transmit antennas and M receive antennas to provide a diversity order of 2M. This scheme does not require any bandwidth expansion or feedback from the receiver to the transmitter.

***Keywords**: Signal Reception; Signal Attenuation; Antenna Diversity; Wireless Communication Systems*

Introduction

Wireless communication systems over the decades have gained popularity because of its flexibility, better reliability, better antenna technologies, lower costs, easier deployment of wireless systems, and the need for mobile communication. It involves sending or transmitting information over a distance without the help of cables, wires etc. The transmission distance ranges from few meters in the case of electronic gadgets' remote control to thousands of kilometers for radio communication. They are generally implemented and administered using a transmission system called radio waves. Today, the requirements of wireless communications are high voice quality, high data rates, multimedia features, lightweight communication devices etc., but wireless communication channel has suffered impairment which is the issue of fading. The fundamental phenomena which makes transmission unreliable is time varying fading (Mark & Zhuang, 2007) which could be a result of many factors such as climatic conditions, increased distance and the possible existence of multiple paths from the transmitter to the receiver thus making the signals arrive at the receiver at different times. This obviously leads to deteriorated signal reception.

When an information signal is transmitted via wireless a communication network, it undergoes many kinds of propagation effects such as reflection, diffraction and scattering due to presence of obstacles such as buildings, mountains and other obstructions. Reflection occurs when the electromagnetic waves impinge on objects which are much greater than the wavelength of the traveling wave. Diffraction occurs when the wave interacts with a surface having sharp

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irregularities (edges). Scattering occurs when the medium through which the wave is traveling contains objects which are much smaller than the wavelength of the electromagnetic wave. These propagation effects create multi-paths of the transmitted signal. At the receiver, the multiple copies of the transmitted signal traverse in different paths. Each of the signals may experience difference in phase shift, time delays, attenuation and distortion that can destructively interfere with one another at the aperture of the receiving antenna (Mietnzer & Hoeher, 2004). 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. Since the main goal of every communication system is to develop high quality wireless communication systems that will generate a high bit rates as well as good performance.

In the above techniques, some amount of preprocessing or post-processing may be required at the transmitter and receiver respectively to enable the receiver to effectively combine the copies or select the best copy. This helps to maximize the signal-to-noise ratio (SNR) at the output. In a switching receiver, the signal from one antenna is fed to the receiver as long as the quality of that signal remains above some prescribed threshold. If and when the signal degrades, another antenna is switched. Switching receivers are the easiest and least power consuming of the antenna diversity processing techniques but periods of fading and re-synchronization may occur while the quality of one antenna degrades and another antenna link is established.

Selection processing technique presents only one antenna's signal to the receiver at any given time (Hourani, 2006). The antenna chosen, however, is based on the best signal-to-noise ratio (SNR) among the received signals. This requires that a pre-measurement takes place and that all antennas have established connections (at least during the SNR measurement) leading to a higher power requirement. The actual selection process can take place in between received packets of information. This ensures that a single antenna connection is maintained as much as possible. In dynamic control however, receivers are capable of choosing from the above processing schemes for whenever the situation arises. In situations of low fading, the receiver can employ no diversity and use the signal presented by a single antenna. As conditions degrade, the receiver can then assume the more highly reliable but power-hungry modes described above. In combining, all antennas maintain established connections at all times (Rappaport, 2002). The signals are then combined and presented to the receiver. Depending on the sophistication of the system, the signals can be added directly (equal gain combining) or weighted and added coherently (maximal-ratio combining). Such a system provides the greatest resistance to fading but since all the receive paths must remain energized; it also consumes the most power. In most of all applications however, the diversity decisions are made by the receiver and are unknown to the transmitter. Schemes employing diversity decisions making at the transmitter and unknown to the receiver are infrequently practiced.

This paper thus presents and improved signal reception approach in wireless communication systems that mitigates the effects of multi-path fading by deploying the use of antenna diversity technique.

Review of Literature

One of the most effective techniques to mitigate multi-path fading in a wireless channel is transmitter power control. If channel conditions as experienced by the receiver on one side of the link are known at the transmitter on the other side, the transmitter can pre-distort the signal in order to overcome the effect of the channel at the receiver (Murthy et al, 2010). There are two fundamental problems with this approach. The major problem is the required transmitter dynamic range. For the transmitter to overcome a certain level of fading, it must increase its power by that same level, which in most cases is not practical because of radiation power limitations and the size and cost of the amplifiers. The second problem is that the transmitter does not have any knowledge of the channel experienced by the receiver except in systems where the up-link (remote to base) and down-link (base to remote) transmissions are carried over the same frequency. Hence, the channel information has to be fed back from the receiver to the transmitter, which results in throughput degradation and considerable added complexity to both the transmitter and the receiver. Moreover, in some applications there may not be a link to feed back the channel information.

Other effective techniques are time and frequency diversity. For time diversity, the same information is transmitted in different time slots. The separation between the time slots has to be at least the coherence time of the channel (Isomaki & Isoaho, 2008). Time interleaving, together with error correction coding, can provide diversity improvement. The same holds for spread spectrum. However, time interleaving results in large delays when the channel is slowly varying. Equivalently, spread spectrum techniques are ineffective when the coherence bandwidth of the channel is larger than the spreading bandwidth or, equivalently, where there is relatively small delay spread in the channel.

In most scattering environments, antenna diversity is a practical, effective and, hence, a widely applied technique for reducing the effect of multi-path fading (Stallings, 2005; Lazano & Jindal, 2010). Antenna diversity has received a great deal of attention in wireless communication systems. The spatial degree of freedom afforded by antenna arrays can be used to mitigate the adverse effects of multi-path and co-channel interference. The idea is to use multiple antennas at the receiver and perform combining or selection and switching in order to improve the quality of the received signal. The major problem with using the receive diversity approach is the cost, size, and power of the remote units (Raut & Badjate, 2013). The use of multiple antennas and radio frequency (RF) chains (or selection and switching circuits) makes the remote units larger and more expensive. As a result, diversity techniques have almost exclusively been applied to base stations to improve their reception quality. A base station often serves hundreds to thousands of remote units. It is therefore more economical to add equipment to base stations rather than the remote units (Li et al, 2009). For this reason, transmit diversity schemes are very attractive. For instance, one antenna and one transmit chain may be added to a base station to improve the reception quality of all the remote units in that base station's coverage area. The alternative is to add more antennas and receivers to all the remote units. The first solution is definitely more economical.

Previous theoretical and simulation study on maximal-ratio combining assume independent fading of the desired and interfering signals at each receiving antenna (Ali, 2013). Such independence occurs if multi-paths reflections are uniformly distributed around receive antennas that are spaced at least half wavelength apart. However, the signals often arrive at the receive antennas mainly from a given direction. For instance, in rural and suburban mobile radio, a high base station antenna typically has a line-of-sight to within the vicinity of the mobile, with local scattering around the mobile generating signals that arrive mainly within a given range of angle or bandwidth.

There has been many other interesting approaches for transmit diversity opined in the communication community. A delay diversity scheme was proposed by Wittneben for base station simulcasting, for a single base station in which copies of the same symbol are transmitted through multiple antennas at different times, hence creating an artificial multi0path distortion. A maximum likelihood sequence estimator (MLSE) or a minimum mean squared error (MMSE) equalizer is then used to resolve multi-path distortion and obtain diversity gain (Srivastava, 2010). Another interesting approach is space–time trellis coding, where symbols are encoded into the antennas through which they are simultaneously transmitted and are decoded using a maximum likelihood decoder. This scheme is very effective, as it combines the benefits of forward error correction (FEC) coding and diversity transmission to provide considerable performance gains (Lazano & Jindal, 2010). The cost for this scheme is additional processing, which increases exponentially as a function of bandwidth efficiency (bits/s/Hz) and the required diversity order. Therefore, for some applications it may not be practical or cost-effective. A new scheme was proposed that increases the BER performance of transmit diversity using transmit antenna selection technique. The performance of multiple-antenna communication systems is known to critically depend on the amount of channel state information (CSI) available at the transmitter (Li et al, 2009). This scheme uses the low-rate feedback for exploiting the channel state information at the transmitter.

Presented in this paper is a simple transmit diversity scheme which improves the signal quality at the receiver on one side of the link by simple processing across two transmit antennas on the opposite side. The obtained diversity order is equal to applying maximal-ratio receiver combining (MRRC) with two antennas at the receiver. The scheme may easily be generalized to two transmit antennas and M receive antennas to provide a diversity order of 2M. This is done without any feedback from the receiver to the transmitter and with small computation complexity.

The main contribution of this research work to the body of knowledge is the generalization and provision of useful extension of the approach to use transmit diversity scheme for space diversity techniques. In other words a binary phase-shift keying (BPSK) modulation is presented and is compared with MRRC. This research work also provides a methodology to compute the path loss exponent which is essential to characterize the propagation environment.

Existing Models

The Okumura model is one of the most widely used models for signal prediction in urban areas. This model is applicable for frequencies in the range 150–1920 MHz (although it is typically extrapolated up to 3000 MHz) and distances of 1–100 km. It can be used for base-station antenna heights ranging from 30–1000 m (Pathania et al, 2014).

Okumura developed a set of curves giving the median attenuation relative to free spaceA_{mu}, in an urban area over a quasi-smooth terrain with a base station effective antenna height (h_{te}) of 200 m and a mobile antenna height $(h_{\Re})$ of 3 m (Kumar, 2011). These curves were developed from extensive measurements using vertical omni-directional antennas at both the base and mobile stations, and are plotted as a function of frequency in the range 100–1920 MHz and as a function of distance from the base station in the range 1–100 km. To determine path loss using Okumura's model, the free space path loss between the points of interest is first determined, and then the value of $A_{mu}(f,d)$ (as read from the curves) is added to it along with correction factors to account for the nature of the terrain. The model can be expressed as

$$L_{50}(dB) = LF + A_{mu}(f,d) - G(h_{te}) - G(h_{re}) - G_{area} \ldots\ldots\ldots\ldots 1$$

where L_{50} is the 50th percentile (i.e., median) value of propagation path loss, LF is the free space propagation loss, A_{mu} is the median attenuation relative to free space, $G(h_{te})$ is the base station antenna height gain factor, $G(h_{re})$ is the mobile antenna height gain factor, and G_{area} is the gain due to the environment. Note that the antenna height gains are strictly a function of height and have nothing to do with antenna patterns (Basharat et al, 2008).

The Hata Model also known as the *Okumura–Hata model,* being an evolved version of the Okumura model, is the most widely used model in radio frequency propagation for predicting the behavior of cellular transmissions in city outskirts and other rural areas (Pathania et al, 2014). This model incorporates the graphical information from Okumura model and develops it further to better suit the need. The model can be used to predict transmission behaviors in urban areas and Suburban areas. The Hata model predicts the total path loss along a link of terrestrial microwave or other type of cellular communications. And is a function of transmission frequency and the average path loss in urban areas. This model is applicable for frequencies in the range 150–1500 and distances of 1–10 km. It can be used for base-station antenna heights ranging from 30–200m and mobile station height ranging from 1-10m (Ifeagwu et al, 2015).

The Hata Model for Urban areas is formulated as following (Kumar, 2011):

$$L_U = 69.55 + 26.16log_{10}f - 13.82log_{10}h_B - C_H + \ldots\ldots 2$$

For small or medium-sized city,

$$C_H = 0.8 +$$

For large cities,

$$C_{H=}$$

Multiple Antenna Technique

The use of multiple antennas for wireless communication systems has gained overwhelming interest during the last decades both in academia and industry (Lazano & Jindal, 2010). Multiple antennas can be utilized in order to accomplish a multiplexing gain, a diversity gain, or an antenna gain, thus enhancing the bit rate, the error performance, or the signal-to-noise-plus-interference ratio of wireless systems, respectively. This can be achieved using spatial multiplexing techniques, spatial diversity and beam-forming techniques.

Spatial Multiplexing Techniques

Spatial multiplexing techniques is known to transmit independent information sequences known as layers simultaneously, over multiple antennas (Lazano & Jindal, 2010). Using *M* transmit antennas, the overall bit rate compared to a single-antenna system is thus enhanced by a factor of *M* without requiring extra bandwidth or extra transmission power. Channel coding is often employed, in order to guarantee a certain error performance. Since the individual layers are superimposed during transmission, they have to be separated at the receiver using an interference cancellation type of algorithm (typically in conjunction with multiple receive antennas).

Beam-forming Techniques

Beam-forming is a technique used to improve the signal-to-noise ratio (SNR) at the receiver and to suppress co-channel interference in a multi-user environment. This is achieved by means of adaptive antenna arrays (Jalloul & Alex, 2006), often referred to as smart antennas or software antennas in the literature. Using beam-forming techniques, the beam patterns of the transmit and receive antenna arrays can be steered in certain desired directions as well as suppressing beam patterns from undesired directions with much interference. The SNR gains achieved by means of beam-forming are often called antenna gains or array gains. The concept of antenna arrays with adaptive beam patterns is not new and has its origins in the field of radar (e.g., for target tracking) and aerospace technology. However, intensive research on smart antennas for wireless communication systems started only in the 1990’s (Lazano & Jindal, 2010).

Spatial Diversity

Diversity techniques help mitigate the effects of fading and improving the error rate of a system by providing multiple copies of the same signal to the receiver via different branches or paths (in frequency, time or even space) so that the probability that all paths will undergo the same amount of fading, or even deep-fades, is reduced to a great extent (Hourani, 2006). Thus, the receiver can be provided with good versions of the signal through one or more paths. The use of time and frequency diversity techniques require extra temporal and spectral resources to ensure that the copies of the signal are sent through different channel conditions or paths. This situation can be avoided by using the additional dimension of space. Some amount of pre-processing or post-processing may be required at the transmitter and receiver, respectively, to enable the receiver to effectively combine the copies, or select the best copy, to maximize the Signal-to-Noise Ratio (SNR) at the output (Srivastava, 2010).

SISO

Radio transmissions traditionally use one antenna at the transmitter and one antenna at the receiver (Murty et al, 2010). This system is termed Single Input Single Output (SISO). Both the transmitter and the receiver have one RF chain (that's coder and modulator). SISO is relatively simple and cheap to implement and it has been used age long since the birth of radio technology (Desai & Makawana, 2013). It is used in radio and TV broadcast and most of our personal wireless technologies (e.g. Wi-Fi and Bluetooth). SISO is shown Fig. 1

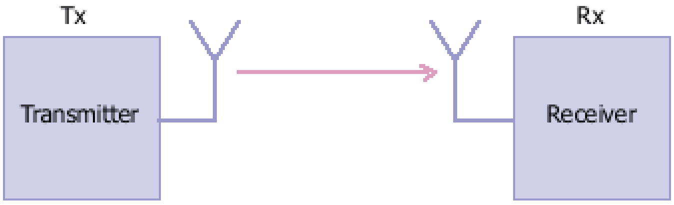

Fig. 2.1 Single Input single Output (SISO) technology (Raut & Badjate, 2013)

SIMO

For improved performance, a multiple antenna technique was developed. A system which uses a single antenna at the transmitter and multiple antennas at the receiver is termed Single Input Multiple Output (SIMO) system (Rohit et al, 2002). The receiver can either choose the best antenna to receive a stronger signal or combine signals from all antennas in such a way that maximizes SNR (Signal to Noise Ratio). The first technique is known as switched diversity or selection diversity. The latter is known as maximal ratio combining (MRC) (Isomaki & Isoaho, 2008). Thus, any signal transmitted from the single transmit-antenna will arrive at all receiver antennas through different sub-channels. It is assumed that each sub-channel, and hence, each channel element is not correlated. As multiple independent copies of the same signal arrive at the receiver, it is possible to exploit the concept of spatial diversity, in this case receiver diversity. Assuming that perfect channel information is available at the receiver, it is possible to use combining techniques at the receiver based on the channel state information. The SIMO is shown in Fig. 2

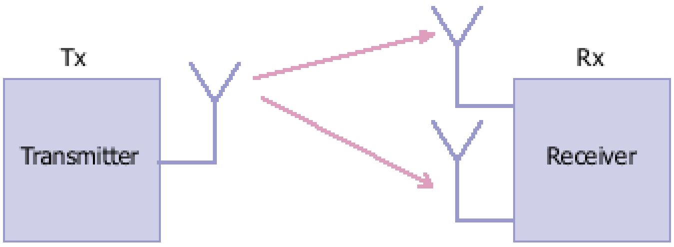

Fig. 2 Single Input Multiple Output (SIMO) (Raut & Badjate, 2013)

MISO

A system which uses multiple antennas at the transmitter and a single antenna at the receiver is named Multiple Input Single Output (MISO) system. A technique known as Alamouti STC (Space Time Coding) is employed at the transmitter with two antennas (Li et al, 2009). STC allows the transmitter to transmit signals (information) both in time and space, meaning the information is transmitted by two antennas at different times consecutively. MISO is shown in Fig. 3

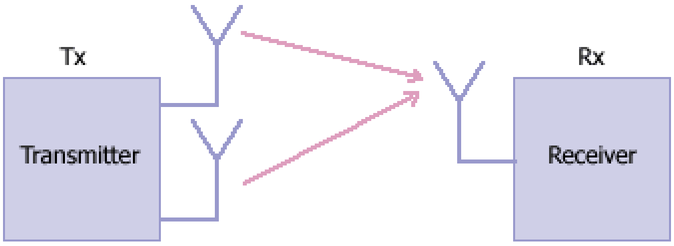

Fig. 3 Multiple Input Single Output (MISO)(Raut & Badjate, 2013)

Multiple antennas (each with an RF chain) of either SIMO or MISO are usually placed at a base station (BS). This way, the cost of providing either a receive diversity (in SIMO) or transmit diversity (in MISO) can be shared by all subscriber stations (SSs) served by the BS (Mohaisen et al, 2004).

MIMO

To multiply throughput of a radio link, multiple antennas (and multiple RF chains accordingly) are put at both the transmitter and the receiver (Badola & Gupta, 2011). This system is referred to as Multiple Input Multiple Output (MIMO) system. A MIMO system with similar count of antennas at both the transmitter and the receiver in a point-to-point (PTP) link is able to multiply the system throughput linearly with every additional antenna. For example, a 2x2 MIMO will double the throughput. A MIMO system is shown in fig.2.4

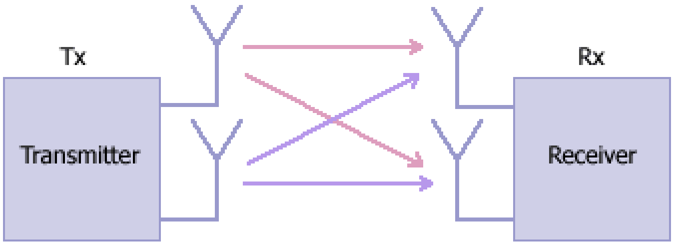

Fig. 4 Multiple Input Multiple Output (MIMO)(Raut & Badjate, 2013)

A MIMO system often employs Spatial Multiplexing (SM) to enable signal (coded and modulated data stream) to be transmitted across different spatial domains (Lazano & Jindal, 2010). MIMO is currently a trending area of research in wireless communications since all wireless technologies (PAN, LAN, MAN, and WAN) try to add it to increase data rate multiple times to satisfy their bandwidth-hungry broadband users (Raut & Badjate, 2013).

Research Methodology

The research is carried out in Enugu urban area in South-East Nigeria using Airtel Nigeria network infrastructure. The field data measurements were obtained from the base stations located in Enugu city. The test environments include Base stations at Coal Camp, Okpara Avenue, State Secretariat, Ebeano Tunnel and Bisalla Road.

The equipment used in measurement include spectrum analyzer, Global Positioning System (GPS); the received signal strength (RSS) was measured with the help of ray-tracer software installed in the spectrum analyzer equipment. The elevations, coordinates and distances from the transmitting base stations and the measurement points were also recorded with the help of global positioning system (GPS). The spectrum analyzer was used to measure the received signal strength level (power received) at a distance (d) from the base station. The ray-tracer software installed in the spectrum analyzer comprises of a scale, which represents the power received in dBm. For every cell in the environment investigated, power received at a distance 100 meters from the base station was measured. Power received at a distance interval of 100 m from the initial test point up till the distance of 1km was measured. The global positioning system GPS was used to determine the geographic coordinate and distance. The field test was done for fifty days between 7am to 5pm at Enugu urban area in South-East Nigeria using airtel Nigeria network infrastructure and five BS cell sites selected in the locations of study. The transmitted signal was measured from the transmitting base station using the spectrum analyzer of model AT5011. The received signal strength were measured and analyzed with the help of software installed and embedded in the spectrum analyzer.

In this paper a Log-distance path loss model was used to predict the propagation loss for a wide range of environment. The path loss exponent of the environment has to be determined so as to know the extent to which signal degradation occurs in a communication channel. Therefore, path-loss exponent, n, of an environment shows the variation of signal loss in an environment. Thus, the path-loss exponent, n, and the received signal strength obtained from field measurement can be used to completely characterize a propagation environment under consideration. A transmit diversity scheme with two transmit and M receive antennas was used in this research, which is equivalent to MRRC with one transmit antenna and 2M receive antennas as they both have the same diversity order for M =1. it was assumed that the channel is known perfectly at the receiver for all the systems. We run the simulations over a range of E_b/N_o points to generate BER results that allow us to compare the different systems. It was observed that whenever the number of receiving antennas is increased the performance of the system increased also which implied that the error probability of the system decreased.

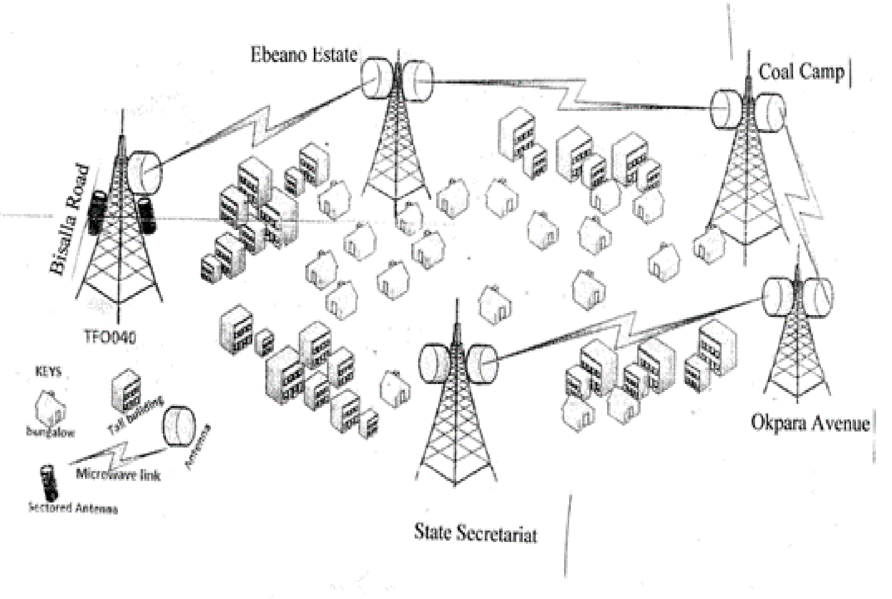

Fig. 5: Test Bed Environment

Distance	RSS(dBm): Conventional Antenna	RSS(dBm): 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

Result Analysis and Discussion

A Path Loss Exponent Analysis

From the figure 6, 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.

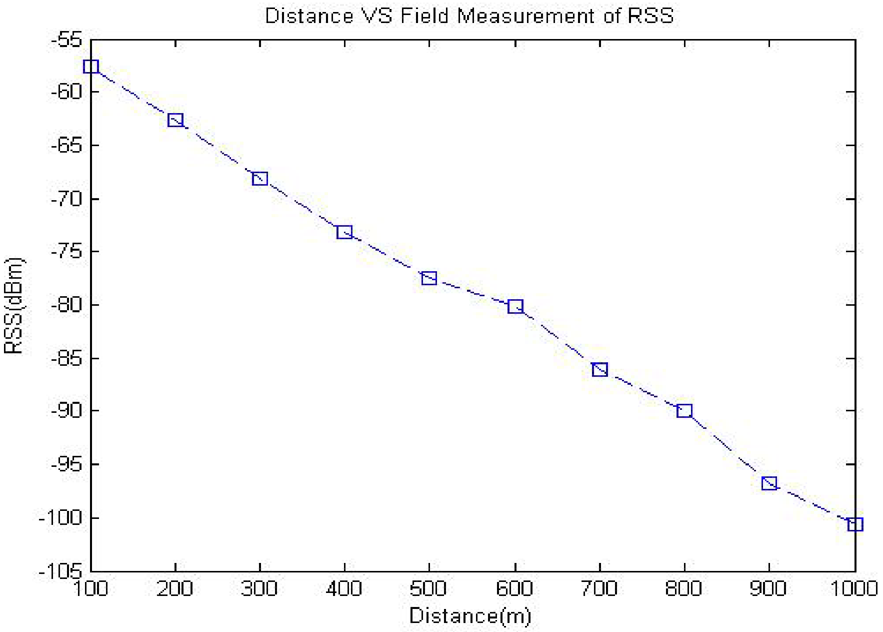

Fig. 6 RSS vs Distance for the characterized environment

Fig. 7 shows the line of best fit that exist between the two graphs, there is a good agreement between the Field RSS and Predicted RSS.

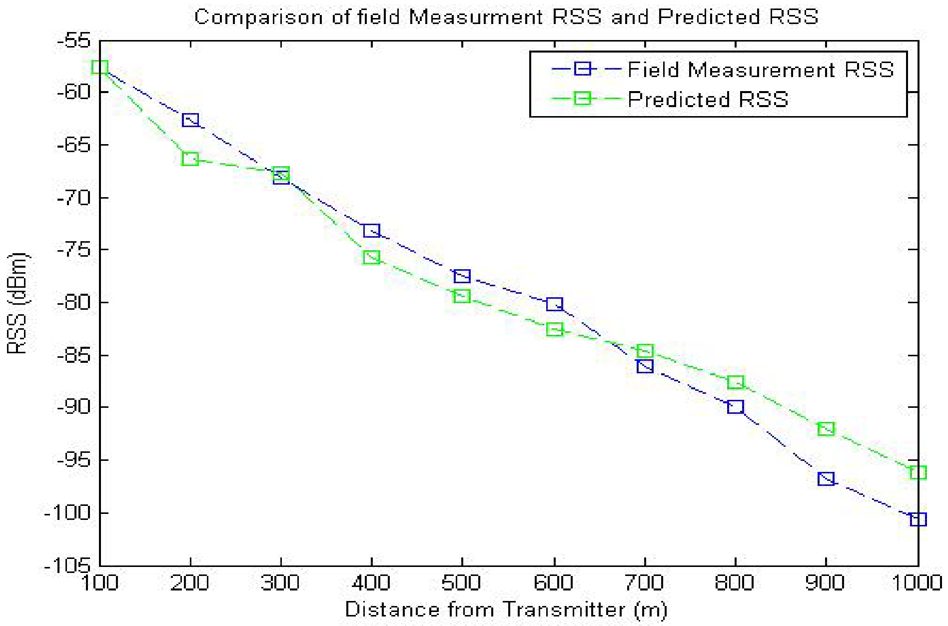

Fig. 7 Measured and Predicted RSS vs Distance

Fig. 8 shows the response of the diversity antenna system in enhancing performance of the WCDMA network by minimizing multi-path fading.

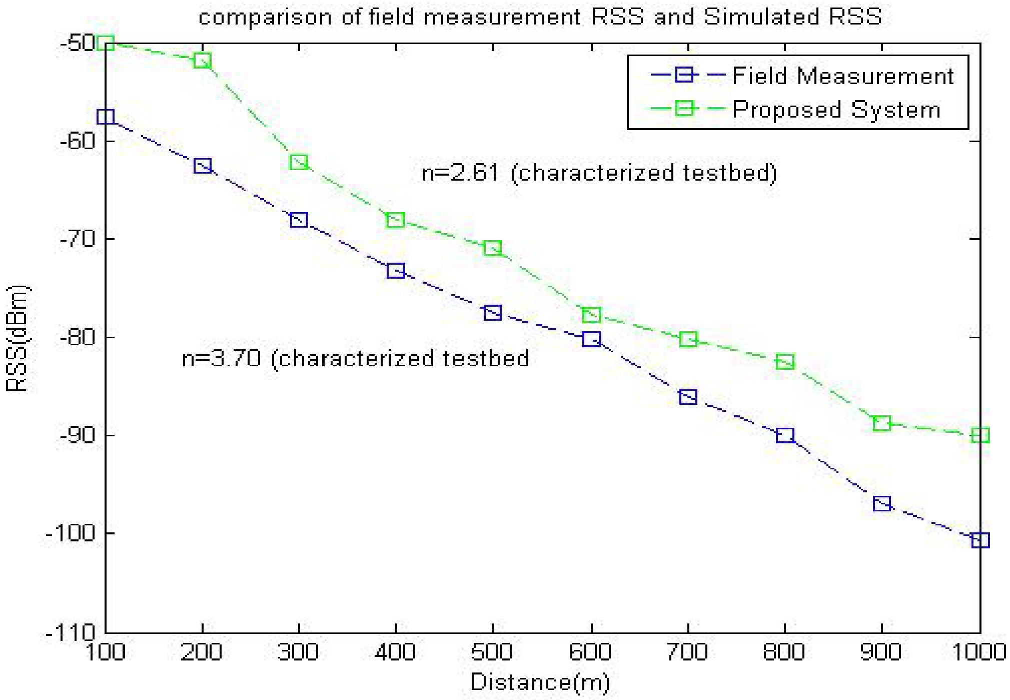

Fig. 8: RSS (Field) and RSS (Diversity) Vs Distance

Error Performance Simulations

The diversity gain in multiple antenna technique is a function of mainly two parameters, which include the modulation scheme and FEC coding. Fig. 9 below shows The BER performance of coherent BPSK with two-branch transmit diversity with one receiver in Rayleigh fading.

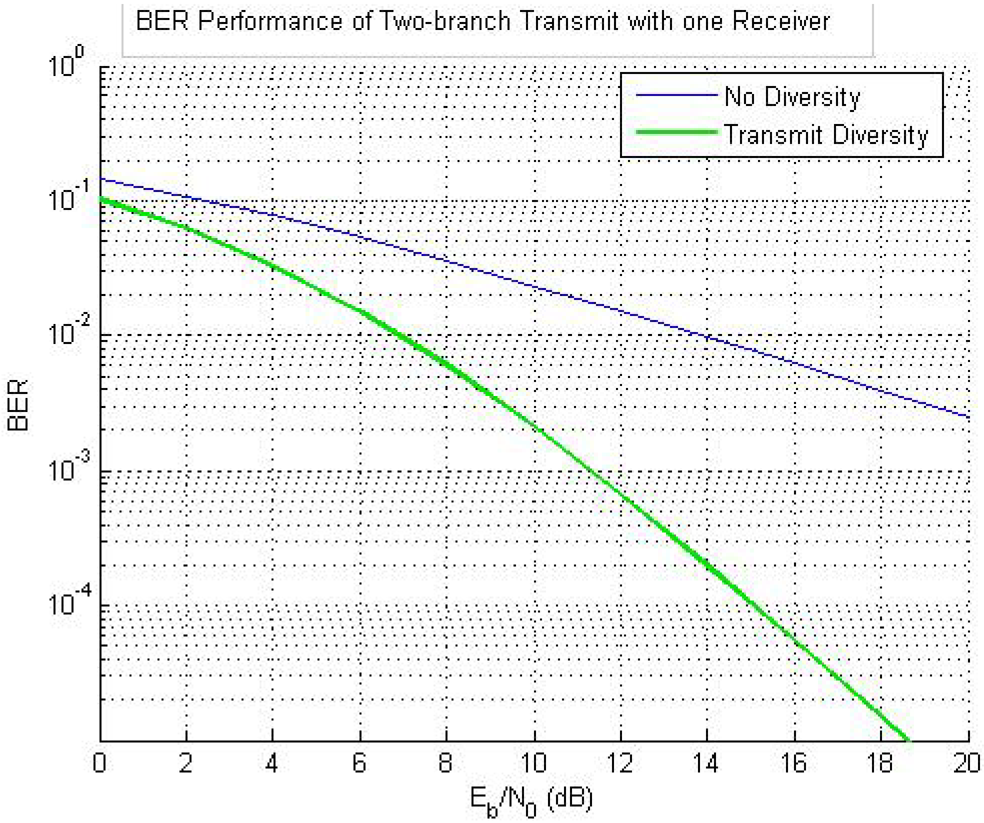

Fig. 9: The BER performance of coherent BPSK with two-branch transmit diversity with one receiver in Rayleigh fading.

Fig. 9 shows the performance of the transmit diversity scheme with two transmitters and a single receiver antenna scheme. From the diagram, at BER of $10^{-4}$the transmit diversity 15dB and no diversity is 0dB therefore, the performance of the channel with transmit diversity scheme of two transmitters and a single receiver antenna scheme is about 15 dB greater than the no diversity channel. The 15-dB gain is attained because the signal is transmitted over multiple channels that experience independent fading and coherently combining them at the receiver, and as a result overcome degradation in the link performance. This performance is also possible as the simulations assume that each transmit antenna radiates full energy in order to ensure the same total radiated power as with the no diversity model. It is obvious that the performance of no diversity (SISO system) in a fading channel is very poor compared to multiple antennas at the transmitting side.

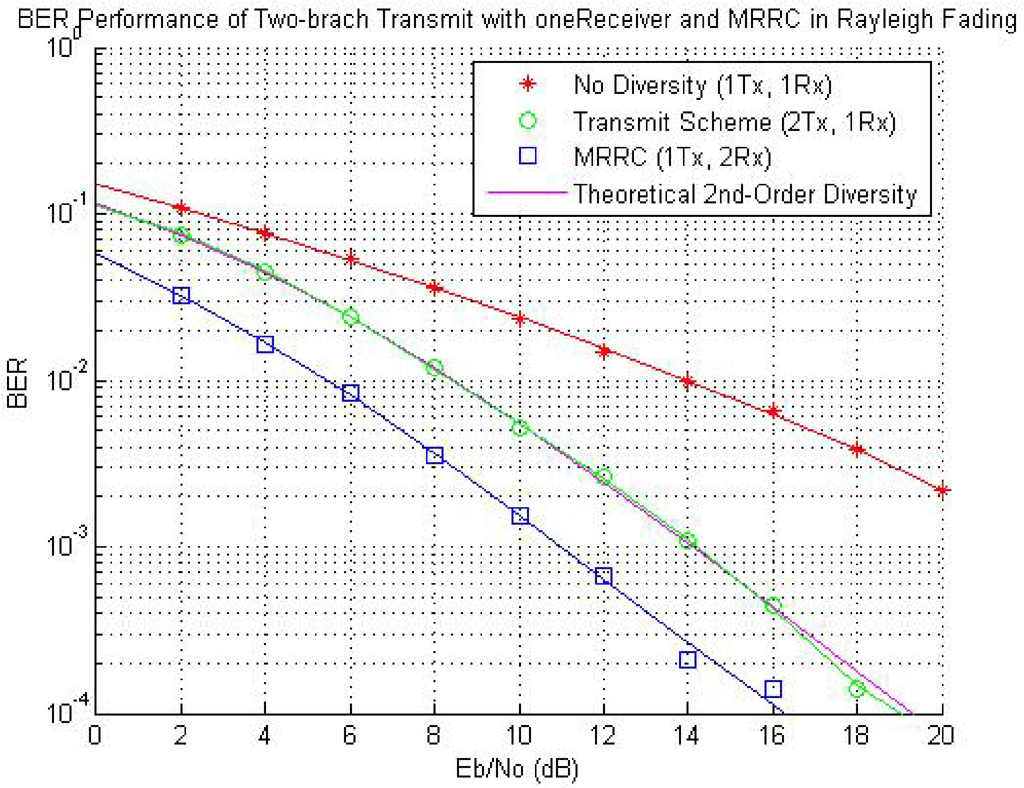

Fig. 10: The BER performance of coherent BPSK with MRRC and two-branch transmit diversity with one receiver in Rayleigh fading.

When signal is transmitted, the antenna array actually processes the signals better in some directions and reduces loss of signal power over some or all of the signal bandwidth. As depicted in the curve, the diversity gain for the transmit scheme (which involves two transmitters and a single receiver antenna) and MRRC (which involves one transmit and two receive antennas) at a BER of $10^{-3}$is about 14 dB and 11 dB respectively. The availability of multiple copies of the same signal at the receiver enables the receiver to effectively combine these multipath components, resulting in diversity gain at the receiver. MRRC provides a better performance when compared with transmit scheme, this is due to the optimal nature of which maximizes SNR at the output. Hence, the probability of experiencing a fade in this composite channel is then proportional to the probability that all the component channels simultaneously experience a fade, a much more unlikely event. If each transmit antenna in the two transmitters and a single receiver scheme was to radiate half the energy as the no transmit channel, the situation would be different. This is explained further (below) in the case of two transmitters and two receiver scheme.

As shown in Fig. 10, the resulting simulation result shows that using two transmit antennas and one receive antenna provides the same diversity order as the maximal-ratio receiver combining (MRRC) system of one transmit antenna and two receive antennas. Also observe that transmit diversity has a 3 dB disadvantage when compared to MRRC receive diversity. This is because we modeled the total transmitted power to be the same in both cases. If we calibrated the transmitted power such that the received power for these two cases is the same, then the performance would be identical.

Conclusion

It is clearly seen that by exploiting diversity, it is possible to effectively mitigate the effects of multi-path fading and in fact, turn it to the advantage of the system. In using antenna diversity, deep channel fades are absent and limited amount of transmitted power is enough to compensate for fading. When compared with convectional antenna system, it reduces the error performance of the signal. From the measured received power in the environment, the path loss exponent was determined using Matlab program to characterize how fast the signal attenuates with respect to the communication distance. The paper has shown that, using two transmit antennas and one receive antenna provides the same diversity order as MRRC with one transmit and two receive antennas. It is further shown that the scheme may easily be generalized to two transmit antennas and M receive antennas to provide a diversity order of 2M. An obvious application of the scheme is to provide diversity improvement at the remote units in a wireless system, using two transmit antennas at the base stations instead of two receive antennas at all the remote terminals. A combination of antenna diversity with spatial multiplexing and/or beam forming to enhance overall performance. Will be a possible direction for future research.

References

AliIrfan (2013). Bit Error Simulation using matlab. *International journal of Engineering Research and Applications*, 3(1), 700-711.

Badola Bharti & Gupta S.C (2011). Improving Reception in Wireless mobile Communication Using MIMO Approach over Rayleigh Fading channels. *IJECT* 2(3), 57-60.

Basharat A., Khokher I.A., & Murtaza S. (2008), CDMA Versus IDMA for Subscriber Cell Density. *International conference on innovation in information technology*. pp 520-524.

Beasley S.Jeffrey & Miller M.Gary (2005),Modern Electronic Communication.*8th Ed., Prentice-Hall* pp 311-315.

Bjerke, B.A., Zvonar, Z.., & Proakis, J.G., (2004), Antenna diversity combining aspects for WCDMA systems in fading multipath channels. *IEEE Transactions on Wireless Communications* 3(1), 97-106

Desai N. & Makawana, G. D. (2013). Space Diversity for communication system-A Review. *International Journal of Engineering Science and Innovation Technology (IJESIT),* 2, 405-410.

Ekpenyong Moses, Isabona Joseph & UmorenImeh (2013). The Impact of Adaptation policies on Channel capacity over Rayleigh Fading with EGC Diversity. *International Journal of wireless & mobile Networks (IJWMN), 5(1),* 127-141.

Ekwe O.A, Anorue E.N, & Okoro C.K. (2014). Evaluating Multiple Antenna Diversity Techniques for Transmission over Fading Channels. *IOSR Journal of Dental and Medical Science.* ISSN 2279-0861, 13, 77-82.

Hourani H. (2006). An overview of diversity techniques in wireless communication systems, Communications Lab, Helsinki University of Technology. Postgraduate course in Radio communication. http://webmail.asst.edu/courses/ VT/OFDM/lecture_fteen_Diversity.pdf

Ifeagwu E.N, Edeko F. O, & Emagbetere J. O. (2015), Characterization of Mobile Radio Propagation channel Using Empirically based pathloss Model for Sururban Environment in Nigeria. *International Journal on Recent and Innovation Trends In Computing and Communication,* 3, ISSN 2321-8169, 3300-3304.

Ifeagwu E.N, Ogu C.J and Alagbu E. (2015). Enhancing the performance of Wideband Code Division Multiple Access (WCDMA) network using Antenna Diversity Technique. *American Journal of computer science and Information Technology. ISSN 2349-3917 AJCSIT, (3)1, 014-025*

Iskander M.F. & Yun Y. (2002), Propagation Prediction Models for wireless communication systems. *IEEE Transactions on Microwave Theory and Techniques,* 50(3), 662-673.

Isomaki P. & Isoaho J. (2008), Diversity Combining. *Turkey Centre for computer science (TUCS). Technical Report* No.884.

Jalloul M. A. & Alex P. S. (2006). Evaluation Methodology and Performance of an IEEE 802.16e System. *Presented to the IEEE Communications and Signal Processing Society, Orange County Joint Chapter (ComSig),* December 7, 2006. Available at: http://chapters.comsoc.org/comsig/meet.htm

Kumar K. A. M. (2011), Significance of Empirical and Physical Propagation Models to calculate the Excess Path loss. *Journal of Engineering Research and Studies.* Vol.2, issue 2, E-ISSN 0976-7916, pp 1-6

Lazano Angel & Jindal Nihar. (2010). Transmit diversity Spatial Multiplexing in modern MIMO systems. *IEEE Trans. Wireless communications,* 9(1), 186-197

Mark J., & Zhuang W. (2007). Wireless Communication & Networks*, Prentice-Hall, 123-127.*

Mietzner J. and Hoeher P. A (2004). Boosting the performance of wireless communication systems – Theory and practice of multiple-antenna. *IEEE Commun. Mag.*, 42(10), ISSN 0163-6804, 40–47.

Mohaisen, M., Wang, Y. & Chang K. (2004). Multiple antenna techniques. The Graduate School of Information Technology and Telecommunications INHA University. http://arxiv.org/ftp/arxiv/papers/0909/0909.3342.pdf.

Murty N. S., Gowri S. & Satyanarayana P. (2010). Transmit Diversity Technique for wireless communication over Rayleigh /flat channels using M-ary Modulation scheme. *International journal of computer science & communication,* 1(1) 279-282.

Pathania, P., Kumar, P., & Rana, B. S. (2014). Performance Evaluation of different path loss Models for Broadcasting Application. *American Journal of Engineering Research (AJER)*, ISSN 2320- 0736, 3, 335-342.

Prasad, M., Siva, G., Siddaiah, P., Reddy, L., & Lekha, K. (2010). Analysis of Fast Fading in Wireless communication Channels. *International journal of systems and Technologies* 3(1),139-145. ISSN 0974-2107.

Rappaport, T. S. (2002). Wireless Communications, Principles and Practice, Second Edition, *Prentice-Hall*

Raut, W. P. & Badjate, S. L. (2013), mimo future wireless communication. *International Journal of Innovative Technology and Exploring Engineering (IJITEE).* ISSN 2278-3075, 2, 102-106

Srivastava N. (2010), Diversity Schemes for Wireless Communication- A Short Review. *Journal of Theoretical and Applied Information Technology,* 15(2),134-143. ISSN 1817-3195.

Stallings, W. (2005), Wireless Communications & Network. *2nd Ed., Prentice-Hall, 67-69*