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Analyzing the Performance of Smart Antenna System in Mobile Communication through Simulation.

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Abstract: *Antenna plays an indispensable role in mobile communication system. In this paper, general descriptions of various types of antenna used in mobile communication system are described. The general block diagram of mobile communication system is also given. Various calculations regarding the channel capacity, antenna gain, transmitted power versus distance etc are also including in this paper. In fact smart antenna systems comprise several critical areas such as individual antenna array design, signal processing algorithms space time processing, wireless channel modeling and coding and network performance.*

Keywords: *Antenna, Antenna gain, Mobile Communication, Signal Processing, Transmitted Power.*

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I. Introduction

An antenna could be a metal like device used for divergent or receiving magnetic force waves that acts as the transition region between free area and guiding structure sort of a conductor so as to speak even in a very longer distance. Without antenna communication is not possible in longer distance. Here the longer distance means the distance which can't be covered by the length of the transmission channel (cable). It is not practically realizable to deploy the cable as the communication channel for the longer distance. For example, for communication between USA and Bangladesh (air distance = about 12,000 km), it is not possible to assign the cable or any physical transmission channel of length about 12,000km[1].

An antenna consists of two parts; Transmitter and Receiver. The antenna at the time of transmitting electromagnetic waves is called transmitting antenna and the same antenna in the time of receiving electromagnetic waves is called receiving antenna. A sending antenna takes waves that are generated by electrical signals within a tool like a radio and converts them to waves that may travel in an open area. The waves that travel in associate degree open area are called free-space waves. The receiving antenna takes free-space waves and converts them into guided waves (electrical signals) that are compatible for cables or wires. So, for the communication between USA and Bangladesh (say a call from Bangladesh to USA), the transmitting antenna located in Bangladesh transmits the electromagnetic waves which are received by the receiving antenna located in USA and hence the communication between them is possible.

To considerably improve the communication link in multipath state of affairs sensible antenna systems are often deployed. Sensible antennas have the potential to supply increased vary and reduced infrastructure prices in early deployments, increased link performance because the system is built-out and redoubled future system capability. Smart antenna system consists of an array of radiating elements able to steer the main lobe beam towards the desired signal and to locate suitable nulls of the radiation pattern in the direction of interferences[3][4].

Also the numbers of antenna elements/ sensors are small. Contrasting to most of the earlier published work that cover only one dimensional condition for DOA estimations and smart antennas. This paper presents associate inclusive effort on sensible antennas that incorporate planate antenna array style, the event of signal process algorithms for angle of arrival estimation (both angle and elevation angle) and adaptative beam forming techniques.

The purpose of this project is to simulate and analysis the design of smart Antenna system. We will present:

- Determine the capacity of a system.
- Calculation of the channel per cell or channel in a cell
- Calculate loss between Transmitter and Receiver in mobile communication

- Observation of Received power Vs distance between Transmitter and Receiver
- Observation of Received power Vs height of the Base Station (BS)
- Observation of Received power Vs height of the Mobile Station (MS)

The rest of this paper is organized as follows. Fundamentals of Smart Antenna System are described in section II. Model of Smart Antenna System are described in section III. Simulation and result discussion is described in section IV. Finally, conclusions are given in Section V.

II. Fundamentals of Smart Antenna system

In this section, we shortly describe the key features of smart antenna system. **Smart antennas** (also known as adaptive array antennas, multiple antennas and, recently, MIMO) are antenna arrays with smart signal processing algorithms used to identify spatial signal signature such as the direction of arrival (DOA) of the signal, and use it to calculate beam forming vectors, to track and locate the antenna beam on the mobile/target.

Smart antenna techniques area unit used notably in acoustic signal process, track and scan radiolocation, astronomy and radio telescopes, and largely in cellular systems like W-CDMA and UMTS.

Smart antennas have two main functions: DOA estimation and Beam forming. Directional antenna receives or radiates electromagnetic waves more effectively in one particular direction than in other directions. This type of antenna radiates or receives electromagnetic waves in all direction except in azimuth plane. This type of antenna is non-directional in azimuth plane and directional in any orthogonal plane.

The technique of substitution single Omni aerial by many directional antennas for decreasing co-channel interference likewise as adjacent channel interference and so increasing the system performance is named sectoring.

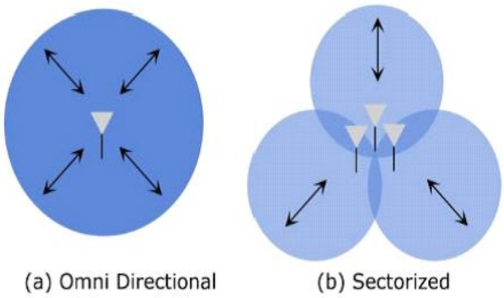

Fig 2.1 Omni directional and sectorized pattern

Using a mobile phone in an urban area is like trying to talk to a friend across a crowded room. There's a lot of interference, and background noise gets in the way of a clear signal. When you're at a party, you can solve the problem by moving within earshot. With mobile communications our best bet could be a sensible antenna. A wise associate antenna generally contains an array of four to twelve antenna components that transmit and receive signals from base station.

Unlike a standard antenna that blankets a massive space with a symbol, a sensible antenna focuses radio energy within the neighborhood of users. This reduces interference from other users who are accessing the same tower, and it extends the range of the signal. With less interference, service providers can increase capacity on their portion of the radio spectrum by as much as a factor of 20, giving more users clearer signals.

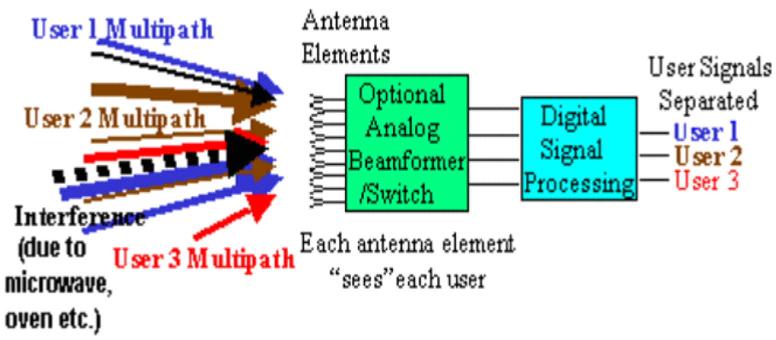

Fig 2.2 Smart Antenna System

2.1 Block Diagram of Antenna System for telephone and mobile communication:

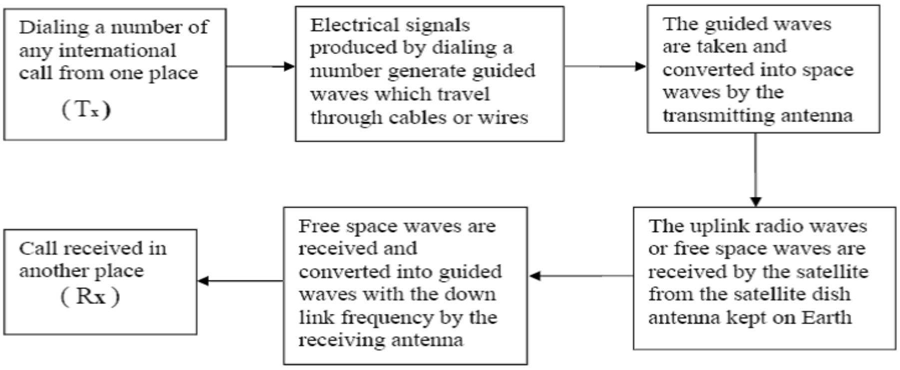

Fig 2.3 Block diagram of antenna system for telephone and mobile communication

III. Model of Smart Antenna System

For micro strip antenna array we use corporate feed network. The corporate–feed network is used to provide power splits. This is accomplished by using either tapered lines or using quarter wavelength impedance transformers. With this method the designer has more control of the feed of each element both in amplitude and phase. Recessed micro strip line feeding techniques is used as this gives a good impedance matching at inputs of the radiating elements [1]. Feed networks in general have certain undesired characteristics that must be carefully monitored in order to minimize any adverse effects on array performance. These characteristics include conductor and dielectric losses, surface wave loss, and spurious radiation due to discontinuities such as bends, junctions and transitions [2].

3.1 Antenna pattern in free space and in mobile environment

The antenna pattern we normally use is the one we measured from the antenna range (open, non-urban area) or an antenna dark room. However when the antenna is placed on the urban or suburban environment and the mobile antenna is lower than the height of the surroundings, the cell site antennas pattern as a mobile unit received in a circle equidistant around the cell site is quite different from the free space antenna pattern. The strongest reception still coincides with the strongest signal strength of the directional antenna. The pattern is distorted in urban and suburban environment [3]. For a 120 directional antenna the back lobe (or front to back ratio) is about 10dB less than the front lobe, regardless of whether a weak side lobe pattern or a no side lobe pattern is designed in a free space condition. This condition exists as a result of the robust signal radiates ahead bouncing back from the encircling in order that the energy may be received from the rear of the antenna. A style specification of the front to back quantitative relation of the transmitting aerial (from the manufacturer's catalogue) is completely different from the particular front to back quantitative relation within the mobile radio setting. Therefore the environment and the antenna beam width determine how the antenna would be used in the mobile radio environment. For example if a 60 directional antenna is used in the mobile radio environment, the actual front to back ratio can vary depending on the given environment. If the close in manmade structure in front.

3.2 Theoretical analysis

Under traditional circumstances radiation from a co channel-serving web site will simply interfere with another channel cell. Directional antenna will cut back the interference within the system by eliminating the radiation to the remainder of its 240 sector. However, co-channel interference will exist even once a antenna is employed, because the serving web site will interfere with the co channel cell that's directly a head. Allow us to assume that a seven cell cellular system (K=7) is employed. The co channel interference reduction issue Q becomes Q = (3N)0.5 = 4.6 and therefore the co channel cell separation D will be found if the cell radius is thought D = qR = 4.6R.

With a separation of 4.6R, the area of interference are the interference receiving cell is illuminated by the central 19 sector of the entire (120) transmitting antenna pattern at the serving cell. If three identical directional antenna are implemented in every cell, with each antenna covering a 120 sector, then every sector receives interference in the central 19 sector of the entire 120 angle at the interfering cell. Therefore, attempt should be made to reduce the signal strength of the interference in this 19 sector. To achieve the numerous gains of C/I within the interference- receiving cell, we should always think about employing a notch within the central of the antenna pattern at the meddling cell.

3.2.1 Cautions in tilting antennas

When a base station antenna is tilted down by 10, the strength of the received signal in the horizontal direction is decreased by 4 dB. But the strength of the received signal 1 below the horizontal is decreased by 3.5 dB only 0.5 dB stronger than in the 0 case. This is very important observation. For e.g., the elevation angel at the boundary of a 2-miles serving cell with a 100ft antenna mast is about 0.5.this means that the serving cell and the interfering cell are separated by only 0.5 at most then by tilting three antenna down by 10, the interference by the interfering cell is reduced by an additional 0.25 dB. This is an insignificant improvement the whole power received is four dB but within the no-tilt case. If the lean is enhanced to twenty, the received power drops by sixteen dB and also the reduction in interference as a result of tilting the antenna is just one dB at the interference cell. So the antenna vertical pattern and also the antenna height play a serious role in justifying antenna tilting. Sometimes, tilting the antenna upward could increase signal coverage if interference isn't a drag.

3.2.2 Umbrella pattern effect

Umbrella pattern can be achieved by the disc one antenna .the umbrella pattern can be applied to reduce co channel interference just as the downward tilted directional antenna pattern is .the umbrella pattern can be used for an Omni directional pattern for a directional antenna pattern. The tilted directional pattern can create notch after tilting 20 more in front of the beam, but the umbrella pattern cannot. Therefore the umbrella pattern might be recommended for every cell site where the interference prevails. The umbrella pattern, within which energy is confined to the immediate space of the antenna, is effective in reducing each co-channel and long distance interference. Additionally in an exceedingly rough area there are several holes (weak signal spots). With a standard antenna pattern, we have a tendency to can’t raise the antenna high enough to hide these holes and reduce co channel interference at a similar time. But the advantage of the umbrella pattern is that we are able to increase the antenna height and still decrease co-channel interference.

3.2.3 Antenna height decreases

The formula is based in the difference between the old and new effective height and not when antenna height decreased, the reception power is also decreased. However on the antenna actual height. Therefore the effective antenna height is the same as the actual antenna height only when the mobile unit is traveling in flat ground. It is straight forward to decrease antenna height to manage coverage within the flat tract space. For decreasing antenna height during a mountainous space, it's troublesome task. Thus a decrease in antenna height would have an effect on the coverage, therefore antenna height become terribly troublesome to manage in an overall arranges. Some space at intervals the cell could have a high attenuation whereas another might not.

3.4 Antenna pattern

The design of various antenna pattern ought to be in line with the piece of ground contour, the population and different condition at intervals the given space. In fact this is often the tough task associate of antenna tilting or use of an antenna pattern may be necessary in bound space so as to scale back interference. Side lobe control is also very critical in the implementation of a directional antenna. Coverage can be control by means of following method:

- When the whole antenna is facing outward the resultant pattern is incredibly troublesome to manage as a result of ripples and deep nulls often kind.
- With skew direction antenna the resultant pattern becomes power tool. Therefore, this configuration is a lot of enticing.

3.5 Analysis of received power intensity of mobile station

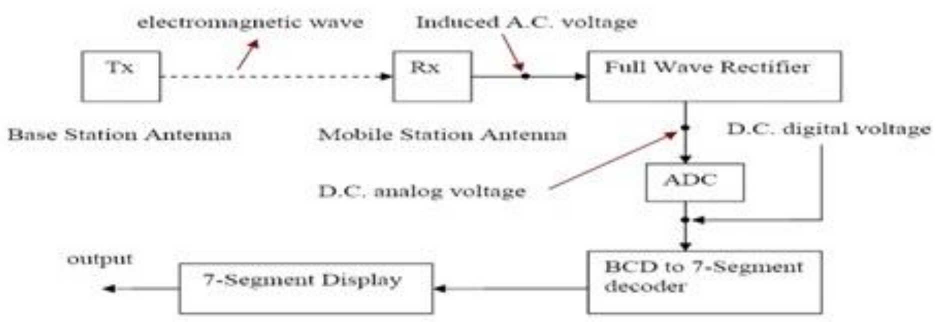

Fig 3.1 Block diagram of analysis of received power intensity of mobile station

When the receiving antenna of mobile station receives the signal from the transmittal antenna of Base Station, then the A.C. voltage evoked may be extracted as an output of receiver antenna. That evoked A.C. voltage may be born-again into D.C. voltage by the utilization of Full wave Rectifier. The obtained voltage is in analog kind which might be born-again into digital kind by victimization the electronic chip known as Analog to Digital convertor (ADC). So we've got to form that reading terribly simply legible for the entire user. So, to do that, we have a tendency to introduce ADC for changing analog into digital type. The output of the ADC is fed into the BCD to Seven phase Decoder so into Seven phase show. The output of the seven phase show is currently legible for the entire user. We, currently will place the mobile station in varied places inside the vary of transmitted power of the transmittal antenna and find the realm wherever the mobile station antenna receives the signal with greatest received power (intensity). So, by the analysis of this experiment, we are able to realize the region wherever the receiver can find the signal and additionally the intense power detectable region of the receiver.

IV. Simulation and Result Discussion

This section presents the simulation results for the Antenna system at different channel conditions. Simulation results include system performance of Antenna system, transmitted power and received power of cell site against distance. We also simulate the Antenna design process and design the antenna using various parameters with various perspectives such as Analyzing transmitted power Vs distance between Tx and Rx.

4.1 Simulation Result of antenna system for Received power

Received power is inversely proportional to the square of the distance between the transmitter and the receiver.

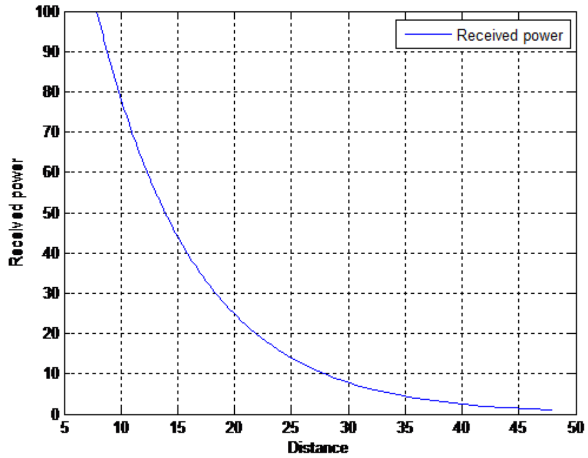

Fig 4.1 Received power verses distance between the transmitter and the receiver.

From fig received power is inversely proportional to the square of the distance between the transmitter and the receiver. From the above we can see that when the distance is increased then received power decreases. In conclusion, the received power decreases with the distance.

4.2 Simulation Result of antenna system for Transmitted power

Transmitted power is proportional to the square of the distance between the transmitter and the receiver.

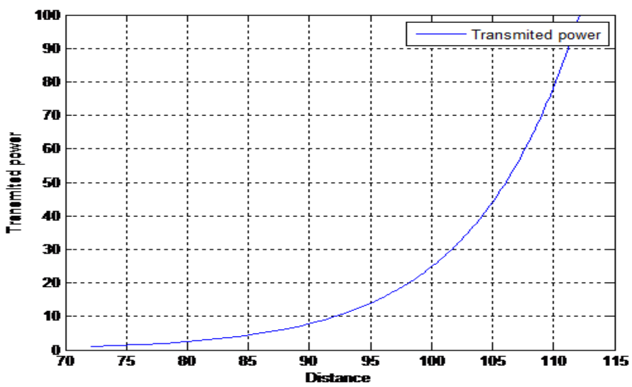

Fig 4.2 Transmitted power verses distance between the transmitter and the receiver.

From fig 4.2 transmitted powers is proportional to the square of the distance between the transmitter and the receiver. From the above we can see that when the distance is increased then transmitted power increases. In conclusion, the transmitted power increases with the distance.

4.3 Simulate the Smart Antenna System (Uplink):

Four Elements operating on 2 GHz with a separation distance 0.075 meters narrowband signals are assumed an authentication code of 10 bits is sent first two users are served only in the presence of additive white Gaussian noise only. Operation is subdivided into three stages: Angle of Arrival Estimation (ESPRIT), Adaptive Beam forming and Signal Regeneration.

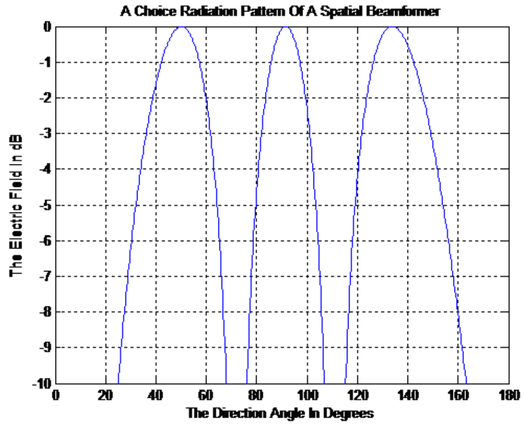

Fig 4.3 A choice radiation pattern of a spatial beam former

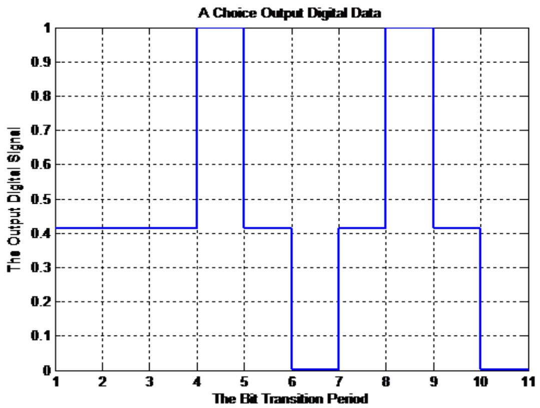

Fig 4.4 A choice output digital data

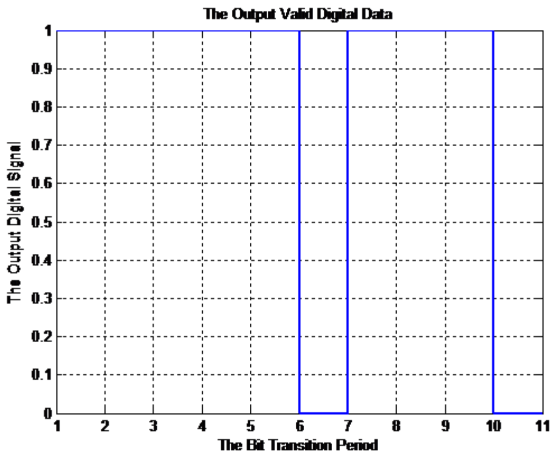

Fig 4.5 The output valid digital data

4.4 Simulate The Smart Antenna System (Downlink)

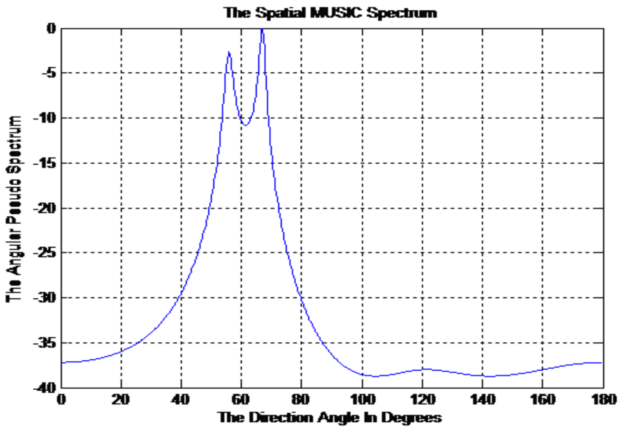

Fig 4.6 The spatial MUSIC spectrum

Two Users are served only in the presence of additive white gaussian noise only operation is subdivided into three stages: Angle of Arrival Estimation(MUSIC), Adaptive Beam forming, Signal Regeneration.

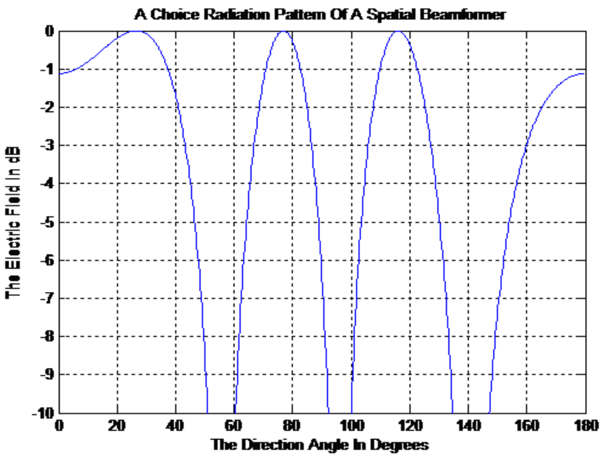

Fig 4.7 Radiation pattern of a spatial beam former

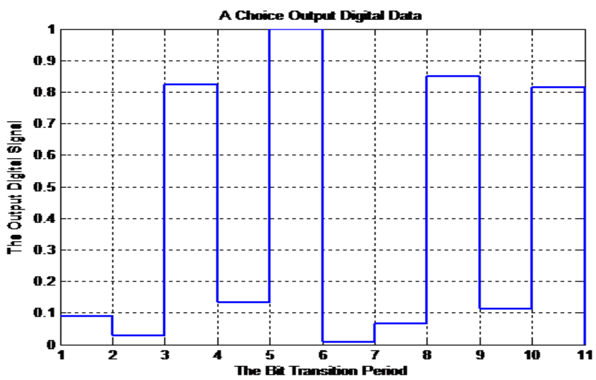

Fig 4.8 A choice output digital data

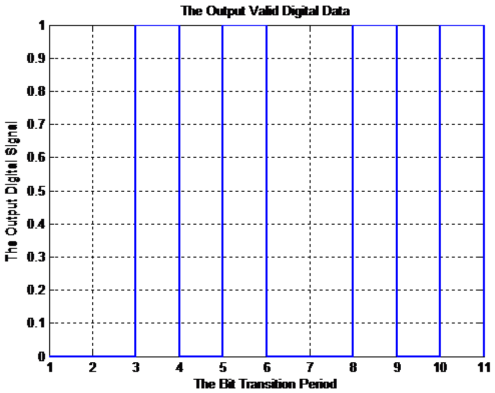

Fig 4.9 The output valid digital data

V. Conclusion

Various patterns of antenna radiation are obtained. Also different calculations regarding the channel capacity, antenna gain, and transmitted power Vs distance are calculated using the C-programming language. The simulation done in MATLAB worked well. Antenna system is modeled using MATLAB to allow various parameters of the system to be varied and tested. In this projects, we observed Loss between Transmitter and Receiver in mobile communication, Received power Vs distance between Transmitter and Receiver, Received power Vs height of the Base Station (BS), Received power Vs height of the Mobile Station (MS). From the simulation, we can see that when the distance is increased then received power decreases, when the distance is increased then transmitted power increases .The presuming analysis about the different schemes such as improving signal quality and quantity aspects and also the reliability of the mobile system are done. Smart antennas immensely improve the potency of wireless transmission and area unit probably to become the quality in use for connections between wireless devices because the technology becomes cheaper it's probably that each one device can utilize sensible antennas.

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