International Journal of Scientific Research in Science, Engineering and Technology
Print ISSN: 2395-1990 | Online ISSN : 2394-4099 (www.ijsrset.com)
doi : https://doi.org/10.32628/IJSRSET229132

Hierarchical Networks Technology and Simulation of An Adaptive Beamforming Antenna

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Article Info
Volume 9, Issue 1
Page Number : 112-119

Publication Issue :
January-February-2022

Article History
Accepted : 01 Feb 2022
Published: 10 Feb 2022

ABSTRACT

This paper focuses on designing and simulation of an adaptive beamforming antenna technology. This was done to ensure that the transmitted signals are beamed in a specified direction for better signal reception in the desired of specified desired stations because the problems of the weak signal emancipate if the antenna is not pointed in the right direction leading to scattering of the signals. This is to say that a beamformoing antenna radiate or receives a greater power in a specified directions allowing for increased performance and reduced interference from an unwanted sources. In order to achieve our aim, a pictorial system design of the antenna was set showing and stating the basic parameters of the systems, the transmitter, channel module, receiver module, display and control module. A practical Simulink software model without and with adaptive beamforming antenna systems were developed, tested, compared and implemented as shown in figure 1 and figure 2 respectively. Simulink model was chosen primarily for its collection of several applications specific blocks that supports different design discipline and specifically for this paper.

Keywords : Adaptive Beamforming, Simulink, Beamforming Algorithm, Mobile Communication, Digital Signal Processor

I. INTRODUCTION

Mobile communication is currently at its fastest growth period in history due to enabling technologies which permit wider deployment. Historically, growth in the mobile communications field has now become slow and has been linked to technological advancement [4, 6]. The need for high capacity and high quality networks estimating coverage accurately has become important. Therefore, for more accurate design coverage of modern cellular networks, design of and simulation of an adaptive beamforming must be taken into consideration in order to provide an efficient and reliable coverage area. Cellular concept was a major breakthrough in solving the problem of spectral congestion and user's capacity [7]. It offered high capacity with limited spectrum allocation without any major technological change. The cellular concept is a system level idea in which a single high power transmitter is replaced with many low power transmitter. The area serviced by a transmitter is called a cell and each small powered transmitter is called base station that provides coverage to a only a small portion of the service area [3]. In GSM network, the air–interface which is also called the Um-interface lies between Mobile Station (MS) and Base Transceiver Station (BTS). The air-interface is made up of physical channels (timeslots) and logical channels. The logical channels consist of information carried over the physical channel [9, 11]. The logical channels are grouped as follows; control channels and traffic channels. These physical channels are facilitated by signaling protocol such as Link Access Protocol "D" Modify (LAPDm) [1, 6] .This protocol is useful during call setup process over the air-interface. Link Access Protocol "D" (LAPD) is used on the Abis-interface, and as well as in the Signaling System (SS7). The SS7 is used on the core network (A-interface to H-interface) with transmission rate at 64kbps on the signaling link (Rappaport, 2003; Gunnar, 1998).The GSM network subscribers, can access the GSM network using the Mobile Station (MS) with valid subscription to access the network. When the MS (which consist of SIM and mobile equipment) is switch on, it is recognized by the closest BTS using Frequency Correction Channels (FCCHs) to transmit in the downlink direction only (Juha, 2003). Thereafter, the subscriber can initiate calls through a set of logical channels. The digital information signal is transmitted over PCM lines at a bit rate of 2.048Mbit/s on Abis-interface, using LAPD signaling protocol from BTS to Base Station Controller (BSC) [11, 8]. The BSC is linked to Transcoder (TC) with A-interface, while the Mobile Switching Centre (MSC) is linked from TC with A-interface. The TC compresses digital signal from 64kbps to 16kbps at the MSC ends (vice versa) and while SS7protocol signaling information remains 64kbps within Network Switching Subsystem (NSS) (Rappaport, 2003).

II. MATERIALS AND METHODS

2.1 MATERIALS

2.1.2 Adaptive beamforming.

An adaptive beamforming is a system of signal processing which is often used in with network of radar antennas or phased array with electronic steering to transmit or receive signal in a desired directions without having to direct the array mathematically.A particular important element in the military applications is the possibility of adaptive beamforming to reduce the sensitivity in the certain directions of arrival in order to counteract hostile transmissions of jamming [12]. An adaptive beamforming is a commonly employed technique that enables systems operation in an interference environment by adaptively modifying the system's antenna pattern so that null are generated in the angular of the locations of the interference sources. This approaches applicable to scenario where multiple antenna elements are individually weighted to produce a desired sensitivity pattern which in certain applications the gain of the single antenna may not be sufficient [9]. Adaptive beamforming can be performed in many ways using adaptive algorithms such that the most of the algorithms are concerned with maximization of the signal to noise ratio SNR [5]. Adaptive array can systems can locate and track signals and dynamically adjust the antenna pattern to enhance reception while minimizing interference using signal processing algorithms [6, 9]. After the systems down converts in to base band and digitizes them, it locates the signal of interest using the direction of arrival algorithm and it continuously track the signal of the interest by dynamically changing the weight and basically the direction of arrival computes the direction of arrival of the signals by computing the delays between the antenna elements. Adaptive arrays are generally more digital processing insensitive and require complete radio frequency portion of the transceiver blind each antenna element and they termed to be more expensive than switched beam systems. In an ever changing propagation of environment such as a mobile cellular network where the arrival angle of the emitter change continuously with time fixed beamforming becomes ineffective [10]. In such environment, adaptive beamforming is used to overcome the problems of the fixed beamforming. Adaptive beamforming combines the input of multiple antenna to form very narrow beam toward individual users in cell. An adaptive beamformer is a device that is able to separate signals collected in the frequency band but separated in the spatial domain. This provides a means for separating a desired signal from interfering signal. An adaptive beam former is able to automatically optimize the array pattern by adjusting the elements of control weights until a prescribed objection function is satisfied by an algorithm deigned for the purpose. Digital signal processor interprets the incoming data information, determines the complex weight and multiplies the weight to each element output to optimize the array pattern. The output response of the uniform linear array is given as,

2.1.2 BEAMFORMING ALGORITHM

Adaptive beamformingis the process of altering the complex weights to maximize the quality of the communication channel. The digital signal processor interprets the incoming data information, determines the complex weights (amplification and phase information) and multiplies the weights to each element output to optimize the array pattern. The optimization is based on a particular criterion, which minimizes the contribution from noise and interference while producing maximum beam gain at the desired direction. There are several adaptive beam-forming algorithms varying in complexity based on different criteria for updating and computing the optimum weights (Gross, 2005). The complex weights, w_k for the antenna elements are carefully chosen to give the desired peaks and nulls in the radiation pattern of the antenna array. In a simple case, the weights may be chosen to give one central beam in some direction, as in a direction-finding application. The weights could then be slowly changed to steer the beam until maximum signal strength occurs and the direction to the signal source is found [13], [14].

In beamforming for communications, the weights are chosen to give a radiation pattern that maximizes the quality of the received signal. Usually, a peak in the pattern is pointed to the signal source and nulls are created in the directions of interfering sources and signal reflections. There are a number of criteria for choosing the algorithm that will produce the optimum weights, they are closely related to each other and therefore the choice of the one is critical in terms of its performance. The most commonly used criteria are minimum mean square error, maximum signal to interference ratio and variance.

2.2 METHOD.

2.2.1 Simulink model.

In any network system, Simulink model is a vital tool software developed by mathematical work which is a graphical programming environment usually deployed for modeling, simulating and analyzing multi domain dynamical systems. Its primary interface is a graphical block diagraming tool and customizable set of block libraries and its primary benefit is the availability of its tool boxes for signal processing and control system development, besides all this advantages, all we need is one environment during the simulation processes which can easily be integrated with other software and automation systems. We used this Simulink software in simulating dynamic behavior of a system that is represented by a mathematical model and this Simulink provides a graphical editor and block libraries and simulating the dynamic systems.

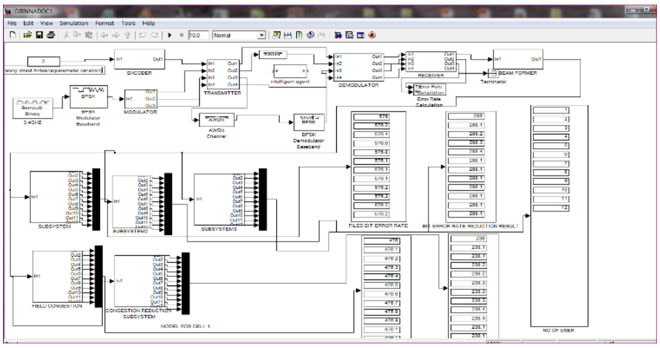

Figure 1 : Simulink model without adaptive beamforming antenna set up diagram.

Simulation of the test bed model was done and both results of when there was no beamforming adaptive antenna elements parameters and when there is adaptive beamforming antenna elements parameters incorporated was compared.

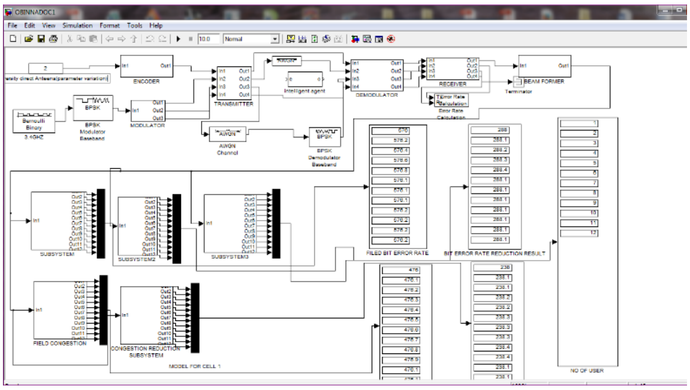

Figure 2 : Simulink model simulation withadaptive beamforming antenna set up diagram.

III. RESULTS AND DISCUSSION

3.1. Result.

The simulated data from the MATLAB simulink module environment is shown in table 3.1 and table 3.2 which shows the percentage improvement in the absence of adaptive beamforming and presence of adaptive beamforming respectively. The results shows in table 2 high number of bit error rate (BER) and congestion in the absence of adaptive beamformingbut better signal reception in the presence of an adaptive beamforming antenna and we found out also that better signal reception can be achieved with the higher number of an antenna elements users respectively.

TABLE 3.1 DATA COMPARISION RESULTS OF IN THE ABSENCE OF ADAPTIVE BEAMFORMING.

S/No (Atenna Element)	BER without beamforming antenna (bit/sec)	Congestion
Antenna Element 1	576	288
Antenna Element 2	576.2	288.1
Antenna Element 3	576.4	288.2
Antenna Element 4	576.6	288.2
Antenna Element 5	576.8	288.4
Antenna Element 6	576.10	288.1
Antenna Element 7	576.12	288.1
Antenna Element 8	576.14	288.1
Antenna Element 9	576.16	288.1
Antenna Element 10	576.18	288.1
Antenna Element 11	576.20	288.1

TABLE 3.1.2 DATA COMPARISION RESULTS OF IN THE ABSENCE OF ADAPTIVE BEAMFORMING

S/No (Atenna Element)	BER with adaptive beamforming antenna bit/sec	Congestion
Antenna Element 1	576	238
Antenna Element 2	576.2	238.1
Antenna Element 3	576.4	238.1
Antenna Element 4	576.6	238.2
Antenna Element 5	576.8	238.3
Antenna Element 6	576.10	238.3
Antenna Element 7	576.12	238.3
Antenna Element 8	576.14	238.3
Antenna Element 9	576.16	238.4
Antenna Element 10	576.18	238.4
Antenna Element 11	576.20	238.1

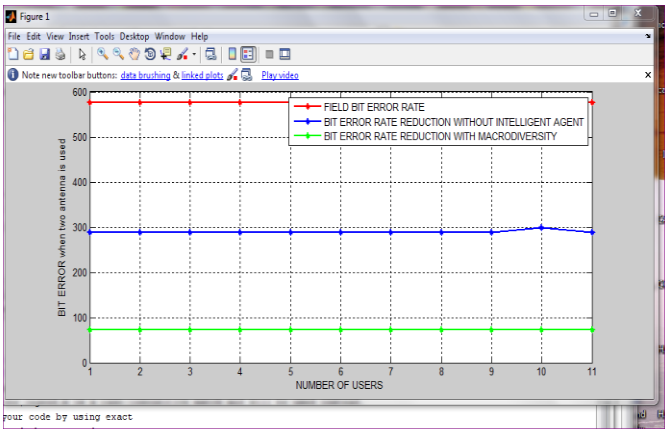

Figure 3. Graphical representation of BER vs Congestion compared when there is no adaptive beamforming antennas.

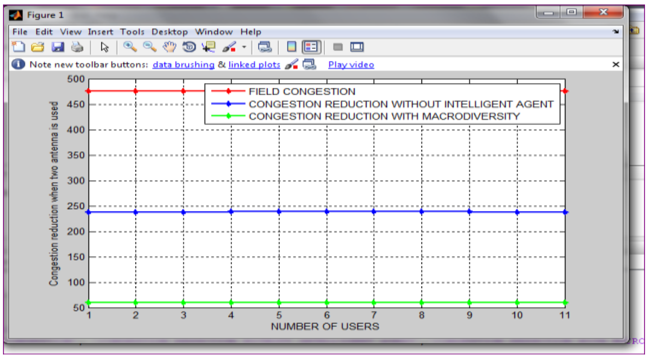

Figure 4.Graphical representation of BER vs Congestion compared when there is adaptive beamforming antennas

IV. CONCLUSION

Designing and simulation of an adaptive beamforming antenna systems as observed from our analysis showed a greater improvement in the interference, congestion and bit error rate reduction capabilities than any other systems. Therefore an adaptive antenna technology proposed here will increase capacity of the mobile radio network thereby making the network operators to accommodate more subscribers per base station and it will the network more stable.

V. FINDINGS

The following findings were made after so many exhaustive research on designing and simulation of an adaptive beamforming technology.

(1) Designing and simulation of an adaptive beamforming antenna for the network under consideration aiming at making the antenna smarter is expensive to design.

(2) There were greater improvement on the performance of the mobile radio netework with adaptive beamforming in minimizing the multiple interference unlike using conventional one.

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Cite this article as :

Uchegbu Chinenye. E, Fagbohunmi Griffin Siji, "Hierarchical Networks Technology and Simulation of An Adaptive Beamforming Antenna", International Journal of Scientific Research in Science, Engineering and Technology (IJSRSET), Online ISSN : 2394-4099, Print ISSN : 2395-1990, Volume 9 Issue 1, pp. 112-119, January-February 2022. Available at doi : https://doi.org/10.32628/IJSRSET229132
Journal URL : https://ijsrset.com/IJSRSET229132