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MITIGATION OF MOBILE NETWORKS INTERFERENCE USING ADAPTIVE ANTENNA

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ABSTRACT

The task of radio network operators is getting tougher and tougher, to meet the constantly increasing demand for higher throughput mobile data services. The limited technical capabilities of network equipment and properties of the radio propagation environment is being the main hurdle. So far, the radio network planners have been successful in choosing proper tools (or equipment), techniques and doing vigilant planning, to create a cellular communication network providing high performance at minimum implementation cost. However, a few of the techniques used are; competent selection of base station site locations or appropriate base station antenna configurations or using repeaters to name a few. In this research work, the effect of topology in a cellular mobile network was investigated. Through MATLAB simulations, some system-level key performance indicators (such as BER, throughput, transmit powers) were studied in other to mitigate the effect of topology in the cellular mobile network. The adaptive antenna was used as a technique for mitigating the effect of topology on the network. The results show that the Adaptive antenna provides an improvement in coverage and capacity of the network at high angles, providing high throughput values.

Keywords

Cellular Mobile Network, Simulation, Topology, Antenna

1.0 Introduction

Wireless Ad hoc Networks are networks in which wireless nodes cooperate to establish network connectivity and perform routing functions in the absence of infrastructure using self-organization. Similarly, Mobile wireless Ad hoc Networks (MANETs) are networks in which nodes communicate through wireless links but move freely [1] . Each node functions, when necessary, as a relay node so as to allow multi hop store-and-forward communications [2]. A key problem associated with mobile wireless ad hoc networks is to conserve energy so as to prolong the battery life and to accommodate the movement of the network nodes. In a mobile wireless ad hoc network, the network topology is formed based on the nodes' transmission ranges and routes of node movement. With the increasing density of base stations

(BSs), and the explosive growth of user data demand, the planning and optimization of heterogeneous networks are facing complicated intercellular interference problems and increased management complexities [3]. The cloud radio access network has been proposed [4]. C-RAN allows operators to reduce the capital and operating expenses needed to deploy and maintain dense heterogeneous networks. It offers several advantages along with spectral efficiency, statistical multiplexing and load balancing gains. However, the heterogeneous cloud radio access network (HCRAN) technique offer a relatively cost efficiency than C-RAN [5]. Although the HCRAN working in coordination with high-power nodes can excellently mitigate co-channel interference, its complex cost structure, resource optimization that is supported by the baseband unit (BBU) pool and its traffic burden on the cloud center require more in-depth studies [6]. Environmental topology can determine base station site locations or appropriate base station antenna configurations in a cellular mobile network [7]. Due to the nature of the environment, a lot of interference can occur in the mobile network thereby degrading the quality of service [8]. These interferences can be caused by high buildings, trees or mountains in the location thereby obstructing signal transmission [9]. Hence, there is need to mitigate the effect of these interferences on the cellular mobile network to improve the quality of service in the network.

Three important aspects of ad hoc mobile wireless networks in general and sensor networks in particular exist viz; location management, energy management; and topology management [10]. Location is an important attribute of senor or ad hoc mobile wireless nodes [11].

In a recent paper, they have described an approach for location management in a sensor network wherein not all the nodes are GPS-enabled [12]. The issues related to energy management and how to achieve energy management at various levels, namely, component, system, and network levels have been described [13].

The aim of this work is to mitigate network mobile network interference using adaptive antenna. The objective in topology control is to reduce energy consumption so as to maintain a specified network topology such as 1-Connected (i.e. the network is connected).

2.0 Research Methodology

The technique adopted in this research is adaptive antenna array. Array beam forming techniques exist that can yield multiple, simultaneously available beams. The beams can be made to have high gain and low side lobes, or controlled beam width. Adaptive beam forming techniques dynamically adjust the array pattern to optimize some characteristic of the received signal. In beam scanning, a single main beam of an array is steered and the direction can be varied either continuously or in small discrete steps.

Antenna arrays using adaptive beamforming techniques can reject interfering signals having a direction of arrival different from that of a desired signal. Multi-polarized arrays can also reject interfering signals having different polarization states from the desired signal, even if the signals have the same direction of arrival. These capabilities can be exploited to improve the capacity of wireless communication systems.

The essential concepts in antenna arrays and beam forming was presented in this work. An array consists of two or more antenna elements that are spatially arranged and electrically interconnected to produce a directional radiation pattern. The interconnection between elements, called the feed network, can provide fixed phase to each element or can form a phased array. In optimum and adaptive beamforming, the phases (and usually the amplitudes) of the feed network are adjusted to optimize the received signal. Smart antenna is one of the most promising technologies that will enable a higher capacity in wireless communications effectively reducing multipath and co-channel interference. This is achieved by focusing the radiation only in the desired direction and adjusting itself to changing traffic conditions or signal environments.

They are capable of automatically changing the directionality of their radiation patterns in the response to their signal environment so they basically attempt to enhance the desired signal power and suppress the interferers by beamforming toward the DoA (Direction of Arrival) of the desired signal and null steering in the case of the interferences. In a Smart antenna system the arrays by themselves are not smart, it is the digital signal processing that makes them smart. The process of combining the signals and then focusing the radiation in a particular direction is often referred to as digital beam forming.

3.0 Mathematical Formulations

Adaptive algorithm technique is based on Least mean square algorithm.

$$e(k) = d(k) - y(k) \qquad 1.0$$

Where;

$e(k)$ -error signal

$d(k)$ -desired signal

$y(k)$ -output

$$y(k) = w^H x(k) \tag{2.0}$$

$$e(k) = d(k) - w^H x(k) \tag{3.0}$$

The fundamental equation is given thus;

$$e(n) = d(n) - w^H(n) * r(n) \tag{4.0}$$

$$w(n+1) = w(n) + \frac{\mu * e(n) * r(n)}{\|r(n)\|^2} \tag{5.0}$$

Where

$e(n)$: complex error

$d(n)$: target output

$w(n)$: J x 1 complex array weight vector

$r(n)$: J x 1 complex array input vector

J : number of antennas in the adaptive array antenna

N : maximum number of iteration

μ : convergence parameter

$\|r(n)\|^2 = rH(n) * r(n)$: normalizing factor

H denotes the complex conjugate and the transform vector.

4.0 **Simulation Parameters**

The simulation parameters are contained in Table 1.0 [14]

Table 1.0: Simulation Parameters

Parameter	**Value**
Design Method	Adaptive antenna
Channel bandwidth (MHz)	3.5
Channel	AWGN
Number of OFDM symbol per burst	2
Building penetration loss	15 dB
Modulation	BPSK, QPSK, 16-QAM or 64-QAM

Area correction factor	-3 dB
SNR (dB)	30
Maximum Doppler shift (Hz)	10
RF frequency	2 GHz
chip rate	3.84Mcps
Number of antennas	4
Antenna spacing (in wavelength units)	0.5
Interferer incident angles (radian)	[0 1*pi/6 1*pi/2 3*pi/4 5*pi/6 pi]
Interference/source power per antenna [db]	2
Traffic distribution	Randomly distributed users within the user defined polygons
Mobile station antenna height	1.5 m
antenna gain	17 dBi
Repeater antenna height	32 m
Eb/No (in dB)	0.1-1.0
Pulse shaping (α)	roll off=0.22

Table 2.0 shows simulation results without adaptive antenna

Table 2.0 Result for Simulation without Adaptive Antenna

Eb/No (dB)	**BER(without Adaptive)**
0.1	0.5346
0.2	0.5278
0.3	0.5227
0.4	0.5206
0.5	0.5185
0.6	0.5149
0.7	0.5114
0.8	0.5093
0.9	0.5081
1.0	0.5057

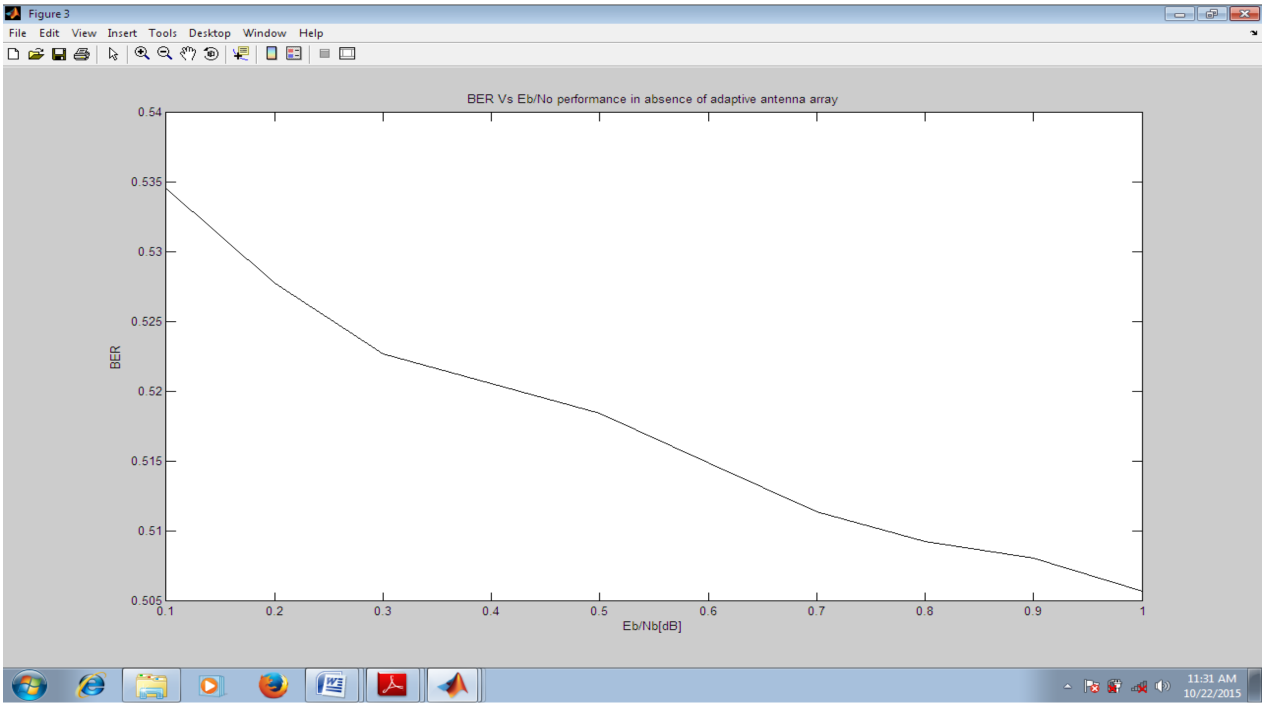

Figure 1.0 : BER Vs Eb/No performance in absence of adaptive antenna array

Figure 1.0 shows that the system is interference limited when no adaptive antenna is present at receiver side. We observed that without any adaptive antenna techniques, the BER approaches to more than 10% even though Eb/No varied from 0.1 to 1dB. This is not an acceptable performance.

The result obtained from the simulation with adaptive antenna is shown in Table 3.0

Table 3.0 : Result for Simulation with Adaptive Antenna

Eb/No (dB)	**BER(Adaptive)**
0.1	0.489
0.2	0.480
0.3	0.4762
0.4	0.4758
0.5	0.4758
0.6	0.4730
0.7	0.4615
0.8	0.4508
0.9	0.4278
1.0	0.4124

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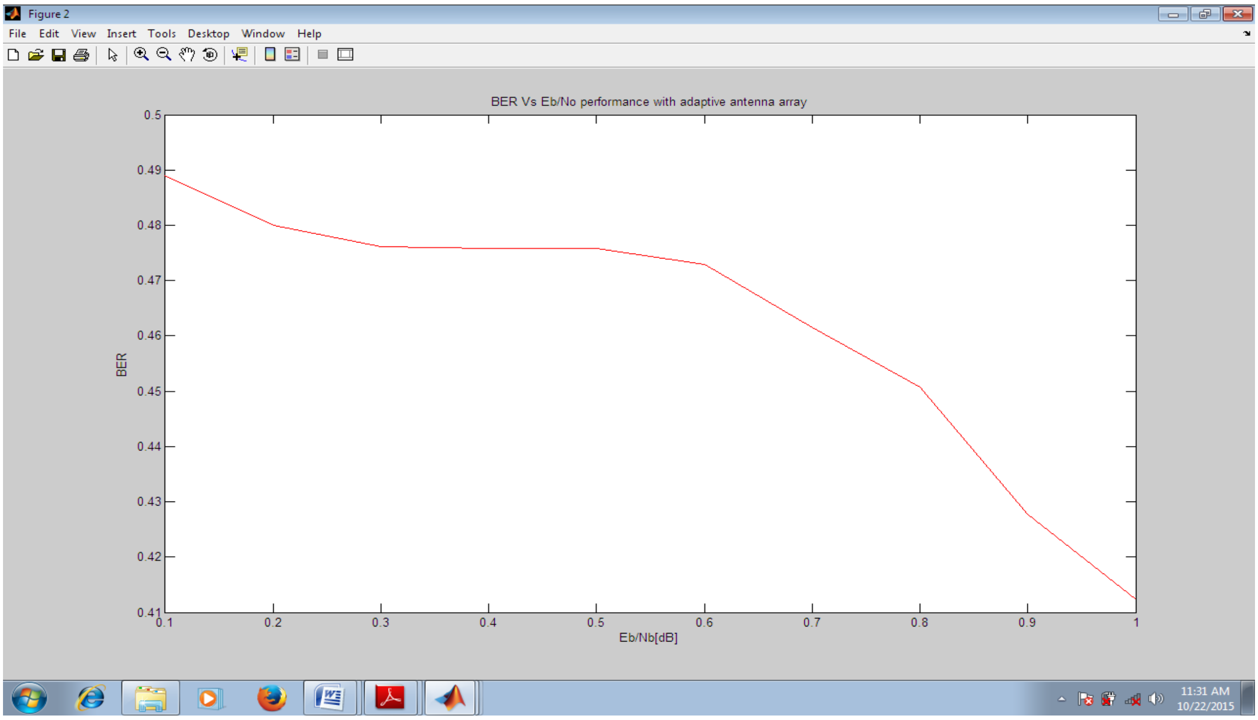

Figure 2.0: BER Vs Eb/No performance with adaptive antenna array

From Figure 2.0, we observed that there is a significant improvement in the BER in the case with adaptive antenna as compared to that of no adaptive in which the BER does not reduce significantly even with increase in the Eb/No.

Table 4.0 contains the comparison for simulation with and without adaptive antenna.

Table 4.0: Comparison for Simulation with and without Adaptive Antenna

Eb/No (dB)	BER(without Adaptive)	BER(Adaptive)
0.1	0.5346	0.489
0.2	0.5278	0.480
0.3	0.5227	0.4762
0.4	0.5206	0.4758
0.5	0.5185	0.4758
0.6	0.5149	0.4730
0.7	0.5114	0.4615
0.8	0.5093	0.4508
0.9	0.5081	0.4278
1.0	0.5057	0.4124

5.0 Conclusion

The bit error rate at uplink with presence and absence of adaptive antenna array in WCDMA system is shown in Figure 1.0 and 2.0 respectively. As expected the system is interference limited when no adaptive antenna is present at receiver side. It was observed that without any adaptive antenna techniques, the BER approaches to more than 10% even though Eb/No varied from 0.1 to 1dB. This is not an acceptable performance. However the BER can be pushed back to an acceptable limit with adaptive antenna array techniques. It was observed that there is a significant improvement in the BER in the case with adaptive antenna as compared to that of no adaptive in which the BER does not reduce significantly even with increase in the Eb/No.

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