Smart Antenna for Wcdma FDD Downlink System

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ABSTRACT *The advancing technologies in mobile communication systems can integrate a wide variety of communication services like high speed data, video and multimedia traffic as well as voice signals. Using WCDMA (Wideband Code Division Multiple Access), the radio access technology in 3G has many advantages like highly efficient spectrum utilization, variable user data rates. The capacity of the system is increased by implementing intra cell reuse concept. The Multipath & Co-channel interference are the two major impairments usually limiting the capacity and performance of mobile communications. Smart antennas can effectively reduce those impairments by focusing the radiation only in the desired direction and placing nulls in the interferers via adaptive updating of weights and adjusting itself to changing traffic conditions or signal environments. This paper discusses about the performance of WCDMA FDD downlink system for different data rates on different multipath channels.*

1. Introduction

Smart antenna also known as phased array, is an electronically steerable directional antenna used in radar and wireless communications to achieve beam forming, MIMO communications and space time coding. Smart antenna consists of an array of antennas that are combined with signal processing in both space and time. Smart antennas helps in improving the system performance by increasing channel capacity and spectrum efficiency, extending range of coverage by steering multiple beams to track many mobiles. In fact, for a smart antenna system antennas are not smart, antenna systems are smart.

WCDMA is one of the five air interfaces for the 3G wireless communications developed within the frame work of International Mobile Telecommunications (IMT) - 2000, as defined by the ITU (International Telecommunications Union). The WCDMA technology is officially known as IMT-2000 Direct spread. The specifications of WCDMA system are developed by the Third Generation Partnership Project

(3GPP), Release 1999, which is a joint effort among standard bodies Europe, Japan, Korea, USA and China.

WCDMA is one of the standards for the 3G world, operating in the combination of FDD (Frequency Division Duplex) and TDD (Time Division Duplex). WCDMA operates in the bandwidth of 5MHZ with the chip rate of 4.096Mcps. WCDMA can provide both circuit switch or packet switch network by using the same transmission channel i.e., user can use the circuit switch mode for phone call and packet switch network for data transfer that can enhance the effectiveness of the network. It inherits the benefit of standardization and open network from GSM system. It is easy to upgrade from GSM through GPRS.

The WCDMA air interface is a Direct spread technology which means that it spreads encoded user data at a relatively low rate over a much wider bandwidth(5MHZ) using a sequence of pseudo random units(chips) at a much higher rates(3.84 Mcps). By assigning a unique code to each user, the receiver, which has knowledge of the code of the intended user, can

successfully separate the desired signal from the received waveform.

2. Designing of Smart Antenna

Smart antenna systems are categorized into Switched beam and Adaptive array systems. Switched beam antenna systems form multiple fixed beams and detect signal strength from these fixed beams and switch from one beam to another as the mobile moves throughout the sector. Whereas Adaptive array antennas use a variety of signal processing algorithms to improve its ability to locate and track various types of signals effectively such that minimizing interference and maximizing intended signal reception by placing the maximum radiation pattern in the direction of desired user and placing nulls in the direction of interferers. This is done by adjusting the antenna weights through adaptive algorithms as shown in Fig.1
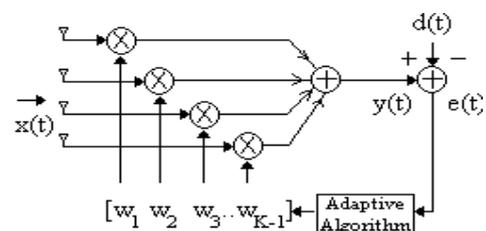

Fig.1 Adaptive Beamforming System.

The purpose of beam forming is to distinguish the spatial properties of signal and noise. The device used for beam forming is called Beamformer. Any Beamformer has to satisfy the following two requirements:

i. Steering capability, whereby the target (source) signal is protected.
ii. Cancellation of interference, so that the output SNR is maximized.

One method of satisfying these requirements is to minimize variance (average power) of the beamformer output.

The Adaptive algorithms are designed to process the following demands:

i. Estimate directions of arrival of all multipath components.

ii. It has to determine whether echo from a certain direction comes from a desired user or from an interferer. Then it can compute weights inorder to increase SNIR as much as possible.

These Adaptive algorithms are classified into 3 types, Temporal Reference(TR), Spatial Reference(SR) and Blind Algorithm(BA).

In this paper SR algorithms like LMS(Least Mean Square) and SMI(Sample Matrix Inversion) are considered. Here the direction of arrival of both desired and interfering signals are estimated, based on the knowledge of physical-antenna-geometry.

2.1 LMS Algorithm

LMS is an adaptive algorithm which uses the estimates of the gradient vector from the available data and incorporates iterative procedure that makes successive corrections to the weight vector in the direction of the negative of the gradient vector which eventually leads to the minimum mean square error. Compared to the other algorithms LMS algorithm is relatively simple because it does not require correlation function calculation nor does it require matrix inversions. It has a stable and robust performance against different signal conditions. It is simple & reasonable and can be used in a highly time-varying signal environment. Since signal characteristics are more dynamic in Mobile communication environment, this algorithm does not allow tracking of the desired signal in a satisfactory manner.

LMS FORMULATION
Weight Vector:
W=zeros((N,max(it)))
Wi= W+mu*conj(e)*X
Where, it: No. of iterations
N: No. of antenna elements
W: Weight of element
Where mu=1/4(abs (trace Rxx))
Rxx=X*X'
X: input gradient vector
e : error signal
d:distance between antenna elements.

Array factor:
AF=AF+W(i)*exp(j*(i-1)*2*pi*sin(theta);
Where theta=-pi/2:0.01:pi/2

Error:
e=conj(s(n))-y(n)
where y=weighted signal. s=desired signal

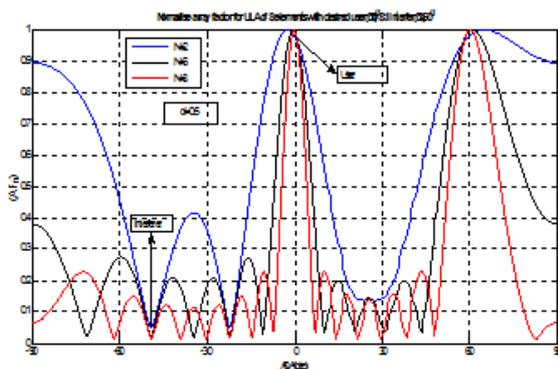### Simulation results of LMS Algorithm

Fig.2 Array factor plot when the AOA of desired user is at 0o & 1 interferer at - 50o with 8 antenna elements.

2.2 SMI Algorithm

The LMS algorithm is a continuously adaptive algorithm and has a slow convergence when the eigen values of covariance matrix are wide spread. When the transmission is discontinuous, a block adaptive approach would give a better performance than a continuous approach. One such algorithm is the SMI, which provides good performance in a discontinuous traffic. However it requires that the number of interferers and their positions remain constant during the duration of the block acquisition. Since it employs direct matrix inversion the convergence of this algorithm is much faster compared to LMS algorithm. It is able to reproduce the signal of interest and is quite efficient with little error.

SMI FORMULATION
$R=E[x(t)x^H(t)]$
$r=E[d(t)x(t)]$
$w_{opt}=R-1r$
$R^\wedge=\sum x(i)xH(i)$
$r^\wedge=\sum d*(i)xH(i)$
$w^\wedge= R^{\wedge-1}r^\wedge$
$e= R^\wedge \; w_{opt}-r^\wedge$
where , R=covariance matrix, r=correlation matrix,
w_{opt} = optimum weight.

The upper and lower limits of summation are N1 & N2, $R^\wedge$ represents estimation of R,
d(t)=desired signal, x(t)=input signal ,e=error.
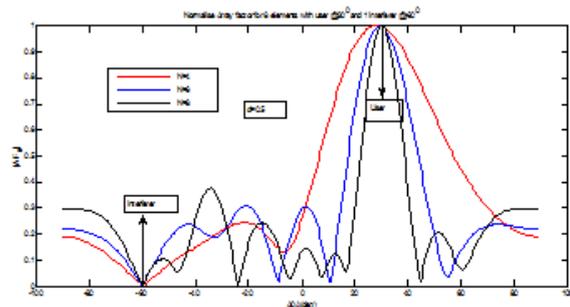Simulation results of SMI Algorithm

Fig.3 Array factor plot for SMI algorithm when AOA of desired signal is 30o & 1 interferer at -60o with increasing antenna elements.

From Fig.2 & Fig.3, it is observed that the Smart antenna can place maximum radiation in the user's direction and nulls in the interferers' direction and also observed that with the increasing antenna elements, the beam width is decreasing and directivity is increasing.

Thus Smart antenna- Embedded block is designed with the help of SMI algorithm.

3. WCDMA Communication system

This paper mainly concentrates on the FDD Downlink (DL) physical layer of the WCDMA. The physical layer is in charge of providing transport support to the data generator at higher layers. This data is exchanged between the higher layers and the physical layer in the form of transport channels. There can be upto 8 transport channels processed simultaneously. Each transport channel is associated with a different transport format that contains information on how the data needs to be processed by the physical layer. The physical layer processes this data before sending it to the channel. This system consists of 7 main Subsystems. They are: WCDMA DL Transmitter channel coding scheme, WCDMA Physical channel mapping, WCDMA Base Station (BS) transmitting antenna, WCDMA channel model,

WCDMA User Equipment (UE) receiving antenna, WCDMA receiver physical channel demapping, WCDMA DL receiver channel.

4. Base station transmitting antenna

The function of BS transmitting antenna is to perform modulation, spreading by a real-valued orthogonal variable spreading factor (OVSF) code, scrambling by a complex-valued gold code sequence code, power weighting and pulse shaping.

In the WCDMA communication system, static AWGN channel and Multipath AWGN channel are used. In this, Multipath channel is considered because the receiver antenna sums up all the different signals such as scaled and delayed versions of the original transmission signal.

5. Simulation Results

Simulation results are presented in the two ways. One by representing Power Vs BER (for different data rates). Another by representing Power Vs BER (with & without Smart Antenna).

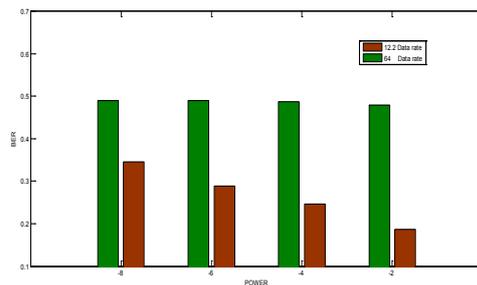**Power Vs BER (for different data rates)**

Fig.4 Power Vs BER

In Fig.4, it is observed that the plot is taken between power and BER for 2 different data rates i.e. 12.2kbps, 64kbps. As the power level is increasing, the BER is coming down.

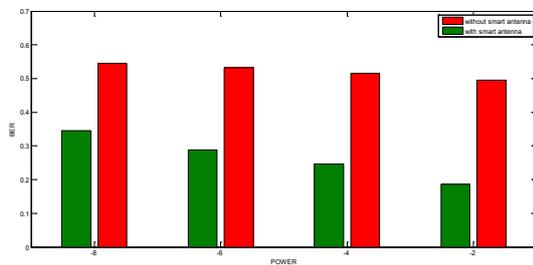**Power Vs BER (with & without Smart Antenna)**

Fig.5 Power Vs BER with & without Smart Antenna

The Fig.5 represents plot between power and BER with & without Smart Antenna in which, the BER is decreasing, with increase in power level. It is observed that, for WCDMA FDD Downlink system, the bit error rates are decreasing from 0.54 to 0.49 for -8 dB to -2 dB power without smart antenna ad from 0.34 to 0.18 with smart antenna. So it is observed that bit error rate is decreasing with increasing power levels.

5. Conclusions

This paper discussed on designing of the smart antenna using SMI algorithm. With the smart antenna directivity increases that inturn reduces radiation effects. So that health hazards are minimized. From the simulation results, it is observed that, BER for WCDMA FDD DL system, for instance at -2dB power level is 0.49 without using smart antenna and an appreciable decrease of BER to 0.18 is observed with smart antenna. By decreasing BER interference is reduced which leads to increase I capacity & coverage area & also reduction in handoffs. Thus a better performance of WCDMA FDD Downlink system is achieved with designed smart antenna .

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