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Wideband Detection for Spectrum Sensing By Cognitive Radio Network Using Smart Antennas

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ABSTRACT: In the project a smart antennas assisted wideband spectrum mobile user detection algorithm by cognitive radios is simulated. In this approach, the wideband spectrum sensing issue is transformed into estimating the number of occupied channels based on the Noise Eigen vector method (NEVM) criterion, and then detecting the occupancy status for each channel by the sample power. The power spectrum is computed by finding the Eigen values of the NEVM criteria. Then the Eigen vectors are used in determining the power spectrum of the signal whose peaks will give information about the spectrum occupied by the mobile user.

KEYWORDS: Wideband spectrum, Smart antennas, Cognitive radio, Noise Eigen vector method, Space division multiple access.

I. INTRODUCTION

Spectrum policies focus on partition of frequency in to fixed bands. The utilization of spectrum on power, interference level, data rates and also type of services are fixed. And fixing of these resources ensures that these resources will be available when needed. If the spectrum has not shared then interferences will be less and higher data rates can be achieved.

Joseph Mitola introduced Cognitive radio [1]. Cognitive radio has been efficiently used to inspect the occupancy of channel, number of free channels, data type to be transmitted and the type of modulation required. To increase improved communications and speed, cognitive radio has been emerged. Thus effective use of spectrum can be made and it is cost dependent on amount of spectrum used and it must also be able to detect the interference caused to other users. Spectrum sensing is the first and foremost step in the implementation of cognitive radio systems. The problem is that when the spectrum is not able to receive the signals at nyquist sampling rate, compressed signals will be received [2].

This solution has made the service providers to endure complicated process with extremely high cost to achieve licensed spectrum. Spatial holes and temporal holes are the two main reasons of spectrum inefficiency which in turn causes under utilization of spectrum.

The low cost digital signal and general purpose processors have made smart antennas work spatially efficient [3]. For use of personal and mobile communications, smart antenna has become more advanced solution. Smart antenna evolved as follows

1. Smart antennas are used as only uplink meaning user is transmitting and the base station is receiving. Thus not only base station gain is increased as well as range and sensitivity is increased.
2. Smart antennas are used as only downlink meaning user is receiving and base station is transmitting. Thus the antenna gain is increased and spatial filtering is done on both uplink and downlink. This is also called as spatial filtering for reduction of the interferences.

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3. The last evolution is space division multiple access (SDMA) meaning more than one user is allocated to communication channel differing by some angle.

Basically smart antennas are the array of antennas consisting of digital signal processors (DSP), having capacity to change the direction of radiation patterns to reduce multipath and co-channel interference.

The access method used in mobile communication which makes use of same set of mobile phone frequencies in given area is what is called as Spatial Division Multiple Access. Therefore the two mobile phones can make use of same set of frequencies. Spatial Division Multiple Access (SDMA) concept is different from Frequency Division Multiple Access (FDMA) and Time Division Multiple Access (TDMA) [4].

The main target is to solve the spectrum sensing problem so that communication speed can be increased and to reduce the interference and fading effects.

II. RELATED WORK

The smart antenna elements use Analog to Digital Converter (ADC) / Digital to Analog Converter (DAC) converters with DSP processor to perform required task using smart algorithms. In current approach we have one set of antenna elements along with trans/receiver multiplexer to perform both reception and transmission. These transmitting and receiving frequencies will be accommodated by antenna elements. We can have two sets of antenna elements:

1. In the first set, the electromagnetic waves far from the sources are received and act as transducer. The signal is being digitized by these array elements using analog to digital converters and are fed to the digital signal processing. Thus angle of arrival (AOA) has been computed and used to detect direction of sources.
2. The second set of array elements acts as actuators which respond according to the processed data in the processor. Actuators send the beam in the required directions and nullify the interferences and jamming directions according to adaptive beam forming algorithms (ABFs). This ABF algorithm is used to direct main beam towards look direction and nulls towards jammer directions as their angular separation is larger than the transmit/receive beam widths.

In case of conventional mobile phone networks, the radio signals are radiated from the base stations in all the directions without knowing the location of the mobile station. But in case of SDMA, radio signals are radiated based on the location of mobile station. Thus SDMA saves network resources and transmission of signal where mobile devices are inactive. Hence reuse of frequency is the main advantage of SDMA

III. METHODOLOGY

For the development of internet services and cellular systems there is wide rise in the usage of broadband technology. Thus traffic will be experienced by mobile and other communication systems. This is because of more number of communication users and also high bit rate data services that are being introduced. This causes the major problem for the service providers. Thus problem increases as the number of user increases which is also referred as co-channel interference. Thus the system performance will get reduced. The other problems which also affect the system are path fading and delay spread caused by monuments or users travelling on vehicles.

Hence the power spectrum of secondary units is determined in this current approach so that the user or the source is detected. It can be done by finding NOISE EIGEN VECTOR METHOD (NEVM) where power spectrum is found out by using the Eigen value decomposition on the array correlation matrix. The number of signal Eigen values and eigenvectors is M and the number of noise Eigen values and eigenvectors are L-M (L is the number of array elements), then the noise Eigen vectors is orthogonal to the array steering vectors at the angles of arrival

$\theta_1, \theta_2, \ldots\ldots\ldots \theta_M$.

The NEVM spectrum is given by

$$P_{NEVM} = \frac{1}{a(\theta)^H E_N E_N^H a(\theta)}$$

Where, $a(\theta)$ is steering vector for an angle θ and E_N is L x L-M matrix comprising of noise Eigen vectors. The NEVM method can be compared with MAXIMUM EIGEN VECTOR METHOD (MEVM), ORDINARY BEAMFORMING METHOD, and MAXIMUM LIKELIHOOD METHOD (MLM) and can be found that NEVM gives the best result.

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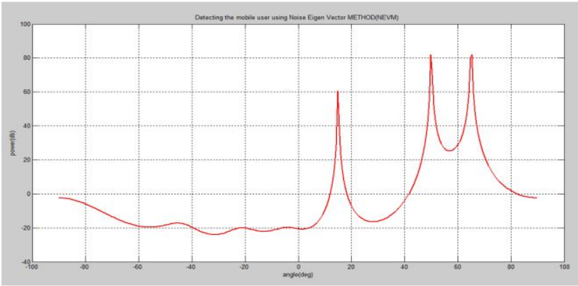
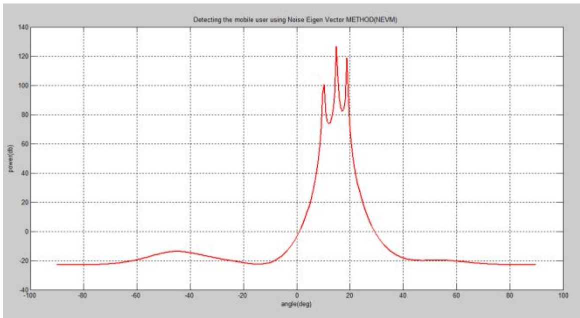
IV. EXPERIMENTAL RESULTS

Below figure (a) shows Less number of antenna elements and widely spaced secondary users where it is assumed that Number of cognitive radio elements=8, Number of sources=3, Amplitude of first em wave=1, Direction of first em wave=15, Amplitude of second em wave=2, Direction of second em wave=50, Amplitude of third em wave=3, Direction of third em wave=60



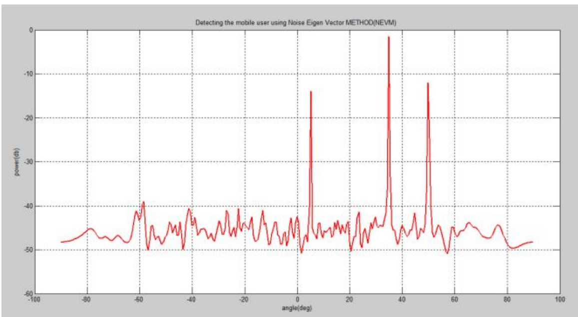
(a)

Below figure (b) shows Less number of antenna elements and closely spaced secondary users where it is assumed that Number of cognitive radio elements=8, Number of sources=3, Amplitude of first em wave=1, Direction of first em wave=10, Amplitude of second em wave=2, Direction of second em wave=15, Amplitude of third em wave=3, Direction of third em wave=19



(b)

Below figure (c) shows More number of antenna elements and widely spaced secondary users where it is assumed that Number of cognitive radio elements=100, Number of sources=3, Amplitude of first em wave=1, Direction of first em wave=5, Amplitude of second em wave=2, Direction of second em wave=35, Amplitude of third em wave=3, Direction of third em wave=50



(c)

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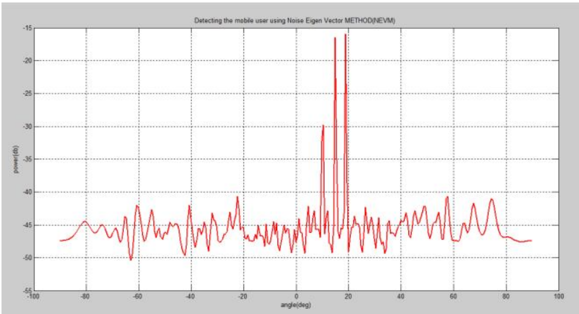
Below figure (d) shows More number of antenna elements and closely spaced secondary users where it is assumed that Number of cognitive radio elements=100, Number of sources=3, Amplitude of first em wave=1, Direction of first em wave=10, Amplitude of second em wave=2, Direction of second em wave=15, Amplitude of third em wave=3, Direction of third em wave=19



(d)

Figure: Detection of secondary users (a) Less number of antenna elements and widely spaced secondary users(b) Less number of antenna elements and closely spaced secondary users (c) More number of antenna elements and widely spaced secondary users (d) More number of antenna elements and closely spaced secondary users

Above figures shows the results of four cases that is (a) Less number of antenna elements and widely spaced secondary users (b) Less number of antenna elements and closely spaced secondary users (c) More number of antenna elements and widely spaced secondary users (d) More number of antenna elements and closely spaced secondary users

V. CONCLUSION

From the above calculations it is found out that NEVM is the best method to detect secondary users (SUs). Hence the spectrum sensing/sharing problem can be solved and interference and multipath fading problems are also reduced thus increasing communication speed.

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