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Intelligent Beamforming To Enhance The Secondary User Performance

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Abstract: Cognitive radio assents the secondary users to access the spectrum of the primary user only when there is a spectrum hole is detected. Hence the looked-for spectral competence cannot be achieved. To improve the spectral efficiency the synchronicity of the primary and secondary users are required and it is achieved by beam forming. Two main problems are existing while beam forming are to achieve the throughput required by the secondary user and to maintain the interference level below the threshold value. The problems are solved by using convex optimization technique and SVD. By using the SVD single channel can be spliced into orthonormal channels; because of that coexistence of primary and secondary users can be implemented and the steering vector is used to improve the directionality of the signal. MIMO system with four antennas is considered for simulation. Using the new proposed scheme it is sure that the MIMO cognitive radio performance will be enhanced.

Index Terms: Cognitive radio, Beam forming, SVD, Convex Optimization.

I. INTRODUCTION

A cognitive radio is an intellectual radio that can be programmed and constituted dynamically. Its transceiver is designed to use the best wireless channels in its vicinity. Such a radio inevitably detects available channels in wireless spectrum, then consequently changes its transmission or reception parameters to allow more concurrent wireless communications in a given spectrum band at one location. This progression is a form of dynamic spectrum administration.[1].

Multiple input multiple output system is widely used to improve the reliability and efficiency of the communication system. The capacity of MIMO is significantly high when compare to SISO system [2]. The benefits include spatial multiplexing gain, diversity gain and interference reduction and avoidance.

Beamforming or spatial filtering is a signal dispensation technique used in sensor collection for directional signal transmission or reception. This is achieved by coalescing elements in a phased array in such a way that signals at specific angles experience constructive interference while others experience destructive intervention. Beamforming can be used at both the transmitting and receiving ends in order to achieve three-dimensional discrimination. The improvement compared with omnidirectional reception/transmission is known as the receive or transmit gain.

Channel state information is the impact created by the channel on the signal which travels through it. Channel state information can be obtained at transmitter by two ways reciprocity principle or feedback method. The reciprocity principle holds good for time division duplex method because, it has identical forward and reverse frequency bands and time lag is also less than coherence time. The feedback method is not limited by the reciprocity requirements. But, the time lag in order between the channel measured at receiver and it's use by transmitter can be a source for error.

The singular value decomposition (SVD) is a factorization of a real or complex matrix, with many useful applications in signal indulgence and statistics. In wireless communication, it is used to split the single channel into orthonormal channels by factorizing the channel matrix.

$$U = AVD^{-1}$$

The SVD will give the orthonormal vectors. The vectors are said to be orthonormal only if the inner product of the vectors is equal to zero.it is represented by

$$\langle X,Y \rangle = 0$$

where X and Y are the two orthonormal vectors.

II. RELATED WORK

In Cognitive radio the secondary usersare allowed to use the spectrum of primary users only when the bands are not used by them. This is achieved by sensing the spectrum. Whilesensing two parameters have been considered. Probability of detection: The probability of a cognitive radio user declaring that a Primary user (PU) is present when the spectrum is occupied by PU. Probability of false alarm: This value denotes the probability of a CR user declaring that a PU is present when the spectrum is actually free.To maximize the achievable throughput for the secondary network the sensing duration has to be designed properly[3].

Coexistence of the secondary user's with the primary user in spectrum sharing is discussed in [4]. The main objective of this is to minimize the transmit power of the cognitive network such that reduce the interference at the PU and also to guarantee the SINR requirement of the secondary users.To achieve this two iterative algorithms are used: Weighted least square (WLS) solution and Distributed power and admission control with active link protection. n efficient spectrum sharing protocol that uses the situation when the primary system is incapable of supporting its target transmission rate is proposed in[5]. he target is achieved by using the orthogonal frequency division multiplexing (OFDM) relaying and the SU acts as amplify

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and forward relays for the PU. The partof the subcarriers are allocated to transmit the primary user signals and the remaining are utilized by the secondary transmission. Joint optimization is used for cooperation, subcarrier pairing and subcarrier power allocation such that the transmission rate of the secondary system is maximized .It is efficiently solved by using the dual decomposition method.

The novel algorithms that iteratively converge to a local minimum of a real valued function f(x) subject to some constraints is introduced in [6]. The two types of algorithms derived are: Traditional steepest descent algorithm and Traditional Newton algorithm. Steepest descent-type algorithm: This algorithm uses Armijo's step size rule and always converge to local optimum. The rate of convergence is only linear. For each iteration the number of correct digits increased by a fixed amount. Newton type algorithms: This algorithm uses the second order derivatives. The rate of convergence is quadratic. The number of correct digits ultimately doubles for each iteration. This algorithm has two disadvantages. They are high computational complexity and no guarantee that the algorithm will converge to local minimum.

The convex optimization and it's models are explained in [7]. [7]also discuss about the Lagrangian duality to solve the duality problems in the multiuser multi-antenna communication. Advantage of using convex optimization are the communication problems are casted into convex optimization problem which facilitate their analytic and numerical solutions, the local optimum which is obtained from convex problem is also a global minimum and Powerful numerical algorithm's are existing to solve the convex problems. Some of the examples of the numerical algorithms are Interior point method, Cutting plane and ellipsoid method and Primal-dual interior point method. Models of convex optimization are linear programming, Second order cone programming and Semidefinite coneprogramming. It also briefly discuss about these models and their application.

The downlink beamforming problem in CR communication system is discussed in [8]. By properly designing the beamforming vector the SU channel gain can be maximized and the interference level is maintained below the threshold. It is difficult to obtain the perfect channel state information (CSI) at the transmitter, because of the feedback overhead. The predefined codebook is used which has the information about the CSI and it is divided into channel direction information (CDI) and the channel magnitude information (CMI). The feedback consists of finite number of bits indicating the index of the predefined codebook. An algorithm is proposed to design the beamforming vector which considers the error associated with the partial CSI and a feedback bit allocation mechanism is also proposed.

III. PROPOSED SCHEME

In existing cognitive radio system the coexistence of the primary and secondary users are allowed only when a spectrum hole is detected.In proposed scheme the coexistence of the users is allowed by implementing a beamforming network in between the source and the transmitter in which each user is having four antenna. The beamforming network used in this scheme is adaptive network.It has an infinite number of patterns and can be adjusted to the requirements in real time.

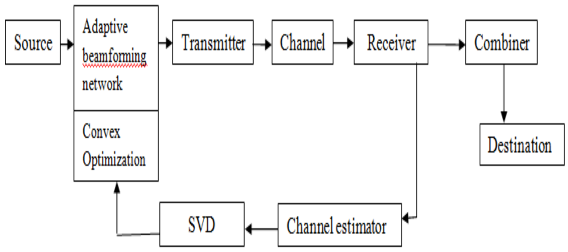

Fig.1.Cognitive System WithMimo-Beamforming

The pattern is changed by multiplying the signal with the ortho normal vectors, the vectors is obtained by estimating the channel matrix. The estimation is done by using the feedback method.

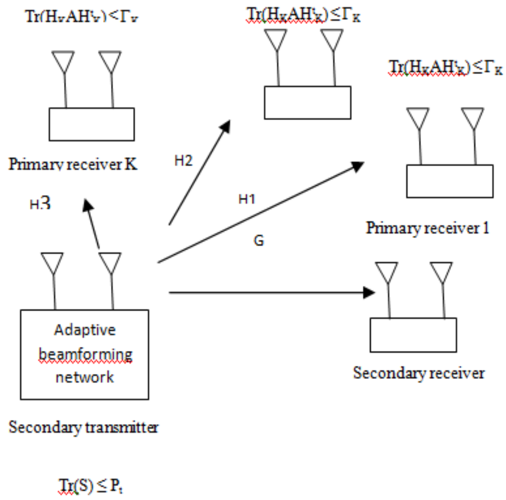

Fig.2.Cognitive Radio Network Where The Secondary User Having Beamforming Network.

$$y(n) = Gs(n) + Hp(n) + z(n) \quad (1)$$

y(n) is the received vector, s(n) is the secondary transmitted vector, p(n) is the primary transmitting signal, z(n) is the additive noise vector and H is a complex channel matrix of secondary transmission. Transmit covariance matrix A of secondary user $A=E[s(n).s^T(n)]$.

The singular value decomposition of A is $V\mathcal{E}V^T$ and rank(A) = d, d is the number of datastreams and Ɛ is a dXd diagonal matrix and σ1,σ2 ,.....σd are the eigen values of matrix A which is the diagonal values of Ɛ. The power Constraint for individual receiving antenna $\sum_{i=1}^{d} \sigma i \leq P_t$ where, σ denotes the power assigned to each datastream and P_t is the total transmit power constraint at secondary transmitter. The total power for each primary receiver $\sum_{j=1}^{M_k} h_{k,j} A h_{k,j}^T \leq \Gamma_k$. $\Gamma_k$is the total power constraints for the kth receiver. The power constraint for individual receiving antenna of the primary receiver $g_{k,j}\ A g_{k.j}^t \leq \gamma_k$.$\gamma_k$ is the interference constraints of each antenna in the kth receiver. Optimal A can be obtained by solving.

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$$\text{maximize} \log_2 |I + GAG^T|$$
$$\text{subject to } \; Tr(A) \le P_t \;\; Tr(H_k A H_k^t) \le \Gamma_k \qquad (2)$$

Optimization used in the above equation is a convex optimization from this the vector which reduces the interference and improves the capacity of the secondary transmission can be obtained. By multiplying that vector with the transmitting signal the interference at the primary user can be reduced.

IV. SIMULATION RESULT

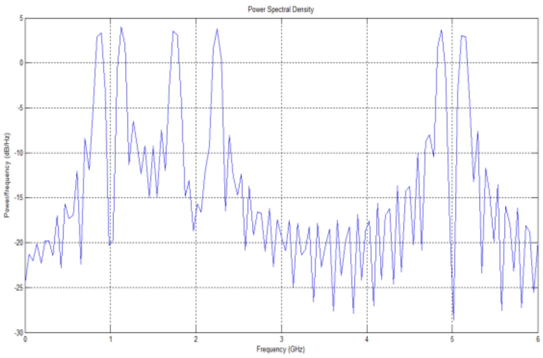

Fig.3.Primary User Spectrum

Fig 3 shows the power spectral density of the primary user from this the spectrum hole is detected by using the threshold based detect

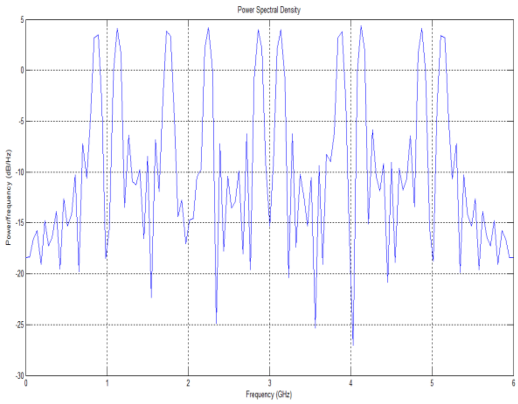

Fig.4.Spectrum With Both Primary And Secondary User

Fig 4 shows the power spectral density which has both primary and secondary users .From this the spectrum can be utilized effectively.

Fig 5 shows the comparison of the channel capacity with and without SVD. From the figure it is observed that the capacity is improved while using the SVD.

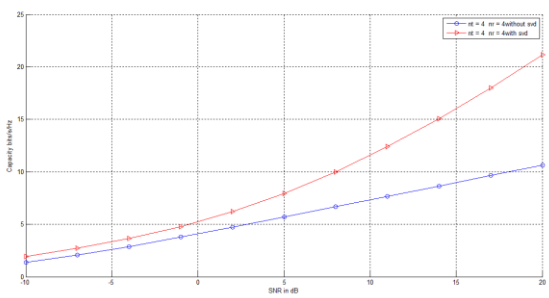

Fig.5. comparison of capacity of the channel with and without SVD

V. CONCLUSION

Because of the latest wireless technologies the spectrum scarcity increased rapidly some of the technologies are cell phones, car key remote control, GPS navigation ,satellite tv broadcast reception and also backend signal , bluetooth, zigbee, wifi. The spectrums allocated to these technologies are not utilized properly. By using the cognitive radio network the unused spectrum are detected and it can be used by the secondary users and the performance of the secondary users is improved by implementing beamforming in the cognitive radio network. Thus by using the beamforming it is possible to improve the utilization of the available spectrum.

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