Survey of Methods for Optimization of Transmit Power for Cognitive Radio Networks

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Abstract: Application of wireless devices and their services are growing at fast speed in few years, and because of this the demand of frequency resources has increased in a dramatic way. Accommodation of these wireless applications and related services within the limited spectrum bands has become a big challenge to the existing fixed spectrum allocation scheme. Thus, there is a need of spectrum regulations that are more flexible. Cognitive radio devices, can dynamically adjust their transmission parameters (transmit power, transmission rate, operating frequency, and etc.), and are capable to improving the spectrum consumption. The spectrum consumption can be enhanced by if primary users (PUs) and cognitive users (CUs) can operate simulateously in the similar frequency band. For this Cognitive radio (CR) is gaining a lot of attention.

Keywords - (CR) Cognitive radio, Secondary user, Primary user, efficient utilization of spectrum, power allocation strategy, Dynamic spectrum access

I. INTRODUCTION

Cognitive radio (CR)

Cognitive radio is a very smart technology which enhances the utilization potency of the scarce radio frequency spectrum and now these days it has attracted incredible interests. A key feature of CR technology is to enable cognitive user (CU) to share the similar band authorized to primary users (PUs) as long because the transmission of secondary/cognitive user does not adversely have an effect on any PU [1]. As a result, the first goal of the CR network is to guard the PUs from dangerous interference induced by the CUs further on meet the standard of service (QoS) demands of CUs. This transmission strategy is named as spectrum sharing [11].

Efficient utilization of spectrum

Recent decades are considered as an era of wireless communication. With the swift boom of communication technologies the spectrum resources are facing scarcity due to huge demands, so the proficient consumption of spectrum is becoming indispensable. Cognitive radio is a new technology and helps the un-licensed users (cognitive users) to work in underlay mode or overlay mode depending on whether the primary user is present or absent [14] respectively and thus helps in spectrum consumption..

Physical insufficiency and in addition proliferation of wireless devices has in current years caused a shortage within the electromagnetic radio spectrum. This has been created worse by the unskilled fullness and under-utilization that has resulted in spectrum holes. So as to enhance the potency of spectrum utilization, more versatile and dynamic spectrum management techniques and rules are needed. Cognitive radio was initial planned by Mitola[15], as a way to realize versatile spectrum management and thereby increase spectrum potency. Cognitive radio helps exploit spectrum holes and allows secondary (unlicensed) transmitters to opportunistically use global organization allotted spectrum or spectrum that is commissioned to primary users while not degrading the potency and capacity[8].In the few years, there are fast developments in the wireless technology, leading to the very rapid rise of wireless devices, good phones, tablets, and hand-held computers. It has been foreseen that the amount of wireless devices will reach around a hundred billion by 2025. This

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explosive development in wireless devices and new wireless applications prompts unprecedented demand on the radio-frequency spectrum. Though, the radio spectrum could be a finite natural resources and therefore the prime section of the RF spectrum (e.g., between thirty MHz to three GHz) has by now been allocated to precise applications or services [10].

Power allocation strategy

Spectrum resources can be utilized fully, transmit power control, dynamic spectrum management are two techniques necessary for (CR) cognitive radio. In these years ,the power allotment techniques for various communication networks with CR functionality received growing attention. The goal is to maximise achievable rates of secondary user i.e. throughput of the SU and hence the capacity of the system by controlling the transmit power of SU and following operational constraints in CRNs : (1) the total amount of interference power caused by SUs to PUs must not exceed a predefined threshold; (2) for each SU, the received SINR must exceed a predefined threshold to guarantee its QoS. The other constraints imposed are transmission power constraints for SU's, mutual interference constraints among SU's , outage probability constraint for SU's and minimum Bit Error Rate (BER).

Dynamic spectrum access (DSA)

Dynamic spectrum access guarantees to produce economical means of utilizing spectrum resources. During a radio system (CRS), unauthorized secondary/cognitive users (CUs) are permitted to dynamically access the spectrum that is authorized to primary users (PUs). To achieve Dynamic Spectrum Access, the CU performs spectrum sensing, in keeping with this sensing information, secondary users begin transmission (a spectrum opportunity)[1].

II. RELATED WORK

Chen Sun et al. [1] in this examines an adaptive-power control scheme for a cognitive radio machine (CRM) in a Rayleigh fading channel. The proposed adaptive-power control scheme outperforms the fixed-power control scheme.It uses two antennas for transmission and two receiving antennas on the bit errors rate (BER) of 10, this method achieves a 3-db gain within the SNR.

Dong in kim et al.[2] performed power allocation and admission control for secondary users keeping in view that constraintssuch as QoS and interference are violated within desired limits. Throughput of primary and secondary networks is investigated through full-size numerical evaluation thinking about one of kind stages of implementation complexity because of channel estimation.

Abdoulaye Bagayoko et al.[3] studies the effect of on the quality of reception of primary user by the transmission of secondary user. The two lower values of mean rate for primary user is chosen, depending at the channel state information for the secondary- user transmit power control and the other for type of constraint for access of spectrum . The obtained mean rates of primary user (PU) are compared with those of selected lower values when secondary user is using different power control strategies. From here a novel power control method is chosen.

Xin kang et al.[4] recollect a cognitive radio (CR) network in which a secondary (cognitive) consumer shares the spectrum for transmission with a primary (non-cognitive) user over block fading (BF) channels. It is assumed that the primary user has a steady-charge, consistent-power transmission, whilst the secondary consumer is able to adapt transmit power and frequency allocation over unique fading states primarily based on the channel kingdom records (CKR) of the CR network. It's far proven by using simulations that the derived new power allocation techniques can reap widespread potential gains for the secondary consumer over the conventional methods based at the interference temperature (IT) constraint to shield the primary transmission, with the same resultant primary consumer outage possibility.

Xin Kang et al.[5] considers a spectrum-sharing cognitive radio network where a bi-directional secondary network is allowed to get entry to the spectrum allotted to a primary person (PU) on a condition that the interference power acquired on the PU receiver is under a desired threshold value. Under this interference power constraint, ithe highest quality energy allocation techniques to gain the essential

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capability limits of a bi-directional secondary network with fading channels are inspected. Particularly, both the ergodic ability and the outage capability are taken into consideration. Closed-shape solutions are obtained for both scenarios except, a key parameter known as interference-transmission-ratio (ITR) is proposed. It is proven that under a given interference power constraint, ITR is the simplest factor that impacts the transmission rules of the secondary network.The transceiver with lower ITR cost has the priority to transmit. Unlike the traditional bi-directional communications network where in concurrent transmission is always most desirable, concurrent transmission isn't always constantly the first preference for bi-directional in terms of maximizing the ergodic capability.

Samuel Montejo Sánchez et al.[6] checks out the effect of combined rate control and power control on the working of a cognitive radio ad-hoc network overlaying a primary user network. The proposed strategies properly modify the transmit power of secondary user to increase the simulatneous transmission probability and such that the primary rate achieved remains above its predefined value.. Two power control techniques are described: rate efficient power control to maximize the secondary capability and energy-efficient method manage to limit the secondary power intake. Numerical outcomes show that it is feasible to enhance the rate and save power in the concurrent transmission region by proposed scheme.

Raikel B. Lopez et al.[7] to solve the power allocation problem a genetic set of rules is advanced and two health features are proposed. The first is used to mitigate the total transmit power intake of the secondary network. The second is a multi-goal function and is orientated to the joint optimization of overall transmit power.Results show a close to-superior performance of the genetic set of rules aided power control scheme based on the multi-goal fitness function.

Oscar Ondeng et al.[8] research game-theoretic transmit power control in a cognitive radio network. This method hybrids iterative water- filling with the hedging algorithm and the ancient matching set of rules. Iterative water-filling helps obtain a fast convergence whereas other algorithms help guard against exploitation. The studying algorithms hired are primarily based on their overall performance in deterministic and probabilistic network environments. The hybrid-adaptive algorithm is shown to provide enhancements on different techniques posted. It additionally plays higher than iterative water-filling and other algorithms taken in isolation.

Fulai liu et al.[9] present an effective combined power control method and spectrum allocation method that uses OFDM. For solving the joint optimization hassle, an effective iterative approach primarily based on particle swarm optimization algorithm is evolved. The proposed approach regulate secondary user's throughput and transmit power.

Gozde Ozcan et al.[10] studies underlay cognitive radio systems to increase the rates that can be achieved through optimal power control under both peak/average transmit power and peak/average interference power constraints under different fading enviornments**.** Results show the fading effects the maximum achievable rate of the cognitive user for different practical constellations and gaussian signals under the both transmit and interference power constraints.

Guanglong yang et al.[11] in this examines the game theory method to solve the problem of power control in CR networks in order to control interference power constraint at PU and the signal-to-interference-plus-noise ratio (SINR) constraint of each CU.

Pratik Tiwari et al.[12] uses a particle swarm optimization (PSO) method to optimise the transmit power taking co-channel interference into view. A system model of multiple secondary users (SU) pairs and one primary user (PU) pair in a spectrum underlay fashion is considered. A weighted fitness function is used to control the transmit powerr target signal-to interference noise ratio (SINR) in desired limits.

Feng Li et al.[13] introduce a method that hybrids Pattern search (PS) optimisation method and genetic algorithm method for power allocation in cognitive radio networks. Rayleigh fading enviornment is considered. The numerical results show that it can solve the power allocation problem in cognitive networks.

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Muhammad Zaheer et al.[14] giving artificial bee colony group optimisation method to optimize the problem to diminish the transmission powers to lower down the interference plus to find out the substitute beam forming weights that help out in decreasing interference.

Table 2.1 Summary of various Resource allocation/Power control techniques

Technique /Algorithm	Year	Method	Findings
MMGA(mixed multi-objective immune cloning genetic algorithm)	2009	MMGA to parameter optimization of the power control and the frequency spectrum allocation in CRNs.	The MMGA can effectively optimize resource allocation in CRNs.
An adaptive-power control scheme for the CRS in a Rayleigh fading channel.	2010	It works By applying transmit power adaptation at the SU transmitter to retain aconstant SNR to the SU receiver,	The method enhances the output SNR and restricts the interference to the PU inside an interference constraint
Point-to-point CR fading channel.	2011	It works as point-to-point CR fading channel with multiple secondary links an d/or multiple primary links.	Results are improved as compared to point-to-point CR fading channel with a single primary link.
The optimal power allocation strategies	2013	A key parameter referred to as Interference-Transmission-Ratio (ITR), which plays a significant role in determining the optimal transmission techniques of the secondary network, is applied	Achieve the ergodic capacity and minimize the outage probability of a fading bi-directional cognitive radio network (CRN)
Two power control strategies RE-PC and EE-PC	2013	Use of joint power and rate control on the secondary link to expand the concurrent transmission region that guarantees the coexistence of primary and secondary links in a CRAHN.	The data rate or the energy efficiency is increased without affecting the performance of the primary network, considerably improving the performance of the secondary network.
GA to solve the optimization problem	2014	By using a multi-objective fitness function, the algorithm implementation can be easily adapted to solve a variety of optimization problems.	Solves many optimization problems in cognitive radio networks using this technique.
A novel hybrid-adaptive algorithm	2015	Algorithm interfacing Iterative Water-Filling with the Hedging Algorithm and the Historical Matching Algorithm	The projected algorithm was found to execute better than IWF and the individual learning algorithms.
An effective spectrum resource allocation algorithm	2015	It is relayed on PSO	It lessens the computational difficulty.
Optimal power control policies for underlay cognitive radio systems	2015	Arbitrary inputs signaling subject to peak/average pass on power andpeak/average interference power restrictions for general fading distributions.	Outcome disclose that Gaussian input gives higher achievable rates at high power levels.
Interference Control in Cognitive Radio Using	2016	Artificaial Bee Colony is nature	Joint beamforming

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Joint Beamforming and Power Optimization by Applying Artificial Bee Colony.		based omputational intelligence technique used to optimise transmit power.	is considered in this method output depends upon the array elements used in antenna.This method gives close to zero interfernce at PU.

III. CONCLUSION

As user data rates are increasing at rapid rates and there is shortage of available spectrum resources, there will be a need of smart and flexible spectrum usage. For improving the spectrum efficiency spectrum sharing and cognitive radio, will continue to achieve tremendous attention.To control the interference in cognitive radio network is one of the major task. Lots of answers have been given to control this problem like two scenarios known to be cooperative and non cooperative that involves control of transmit power. Many solution approaches are given in order to optimise the transmit power of cognitive users keeping SINR of cognitive users over the target value, subject to interference power constraint at primary user.The two approaches using Particle swarm optimization[12] and Artificial Bee Colony optimization[14] gave better results as compared to the other methods discussed. Still there is a scope of improvement in the results obtained throgh various methods discussed above and by using a better computational intelligence technique to implement cognitive radio desired results can be achieved.

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