International Journal of Control Theory and Applications

ISSN : 0974-5572

Volume 10 • Number 32 • 2017

A Survey on QOS Parameters in Cognitive Radio with Swarm Intelligence Optimization

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Abstract: In present scenario, the user demands has been increasing and it is important to design a Cognitive Radio (CR) based system. The main objective of this paper is to analyze and evaluate the Quality of Services (QoS) parameters with their fitness function. The research in the cognitive radio has been done in certain area and the researcher use the QoS parameters have discussed in this paper. The swarm intelligence optimization algorithms like Ant Colony Optimization (ACO) and Particle Swarm Optimization (PSO)used in previous papers to improve the quality of services parameters are also discussed.

Keywords: Cognitive Radio, Quality of Services, Ant Colony Optimization, Particle Swarm Optimization.

1. INTRODUCTION

The Radio Spectrum is one of the most usable parts of the electromagnetic spectrum and lies in the range of 3 Hz to 3000 GHz. Now a day the technology is growing and numbers of users are increasing accordingly, with this high demand of users the interference problem also arises. So, to avoid interference the radio spectrum is regulated by national laws and co-ordinated by ITU [1].

It is also noted that most of the time the spectrum is lying free and this is shown in figure 1. Sometimes it is heavily utilized and rest of the time it is lying free, so due to this the spectrum scarcity problem [2] is arises. To resolve that problem new technique is designed i.e. Cognitive Radio.

The radio spectrum is divided into licensed and unlicensed users. The licensed users are not properly used spectrum all the time and most of the time it is lying free and due to this spectrum scarcity problem [2] arises. So, to resolve that problem J. Mitola in 1999, introduce a technology called “Cognitive Radio” [3]. A CR is a radio that can be programmed and it automatically detects best available free channels in radio spectrum and shifts users to that channel.

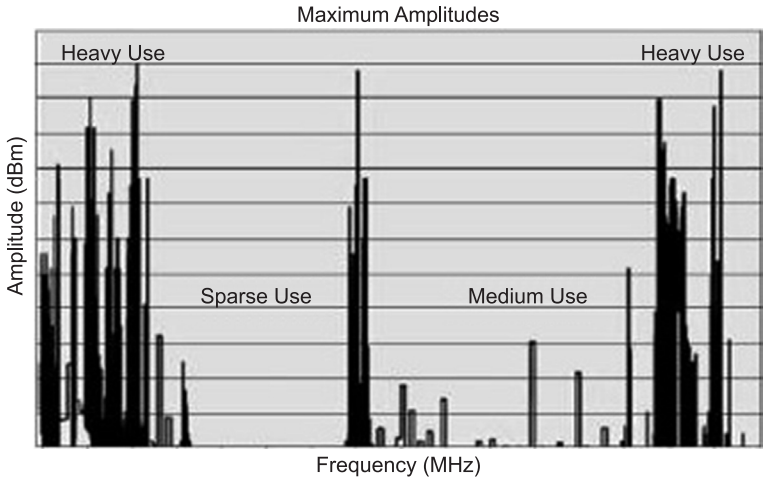

Figure 1: spectrum utilization

The FCC published a report in November 2002, design a new spectrum strategies to resolve the overcrowding bands [4] and allowing SU to use licensed band accordingly. The one of the main reason behind designing the CR is to efficiently utilize limited radio spectrum by dynamic spectrum access [5]. Earlier, with the usage of conventional wireless system the radio access networks and spectrum bands are statically assigned to mobile systems. Due to this conventional system only some part of band are highly congested and other are present with low traffic. So, while using dynamic spectrum access the usage of limited radio resource can be optimized and the capacity and control of the wireless system can be highly improved.

The four main functions of Cognitive Radios are spectrum sensing, spectrum management, spectrum mobility, spectrum sharing.

- Spectrum sensing - it is the one of the main function that it detects the unused spectrum and sharing it with other users without any harmful interference.
- Spectrum Management - it maintains the user's needs and provide them best available channel for communication.
- Spectrum Mobility - it defines the process when the cognitive radio user's exchange its frequency of operation. Its main target is to use the spectrum in dynamic manner and the best channel to the users.
- Spectrum Sharing - spectrum sharing cognitive radio networks allows cognitive radio users to share the spectrum bands of the licensed users. It provides the fair spectrum scheduling method.

Regarding these functions the CR system also satisfies the QoS parameters. So, that the secondary users use the primary users band easily. The QoS parameters are minimum power consumption, minimum bit error rate, maximum spectral efficiency, minimum interference and maximum throughput.

In this paper, section 1 discusses the basic introduction of the Cognitive Radio system. Then comes to next section, section 2 it describes the literature survey. In section 3 the discussion of various algorithm like genetic algorithm, simulated annealing, Ant colony optimization, ABC algorithms are discussed. In section 4 the comparison analyses done and then after conclusion with references end the paper.

2. RELATED WORK

Seshadri Binaya Behera et. al., [6] works on particle swarm optimization technique which is used to optimize the QoS parameters of Cognitive Radio system and these parameters are helpful to enhance the electromagnetic

spectrum. The author in this paper works basically on resource allocation problems and with the usage of greater numbers of particles the swarm increases the fitness values.

Ismail AlQerm et. al., [7] proposed an adaptive multiobjective optimization scheme (AMOS) for CR resource management to improve spectrum utilization and evaluate network performance. In this paper, the AMOS is employed for the optimization phase in the CR's decision making engine using six objectives functions and AMOS uses adaptive Genetic Algorithm for evaluating certain parameters like minimum power consumption, minimum BER, maximum throughput, minimum interference, minimum delay and maximum spectral efficiency. Later on, AMOS is compared with other meta-heuristic techniques such as Ant- Colony optimization (ACO), Artificial Bee colony optimization (ABC), Particle Swarm Optimization (PSO) and GA proposed by Newman and achieves the highest score and has the fastest convergence compared to other techniques.

Kiranjot Kaur et. al., [8] proposed Simulated Annealing optimization technique. In this paper, SA has been used to meet the quality of services (QoS) parameters that is determined by the users in terms of minimum transmit power, minimum BER, maximum throughput, minimum interference and maximum spectral efficiency. Then, after Simulated annealing compared with the genetic algorithm for various QoS parameters and it has been observed that SA is outperforming GA in CR system optimization.

Ali h.Mahdi et. al., [9] proposed the Adaptive Discrete Particle Swarm Optimization (ADPSO) and the author discussed that the Genetic Algorithm (GA) is a well-known evolutionary algorithm for adaptation and optimization of CR systems. But the convergence speed in GA is low. Then after conventional Particle Swarm Optimization (PSO) has been used in the CR systems but it only reduce the computational cost of GA. Then, the research based on ADPSO algorithm for adaptation of transmission parameters and achievement of Quality of Service (QoS) requirements of a CR node using multi-objective optimization. Hence, the Simulation results showed that ADPSO has faster convergence speed and high fitness values compared to GA and the conventional PSO.

Nan Zhao et. al., [10] proposed mutated ant colony optimization (MACO) to optimize cognitive radio system. The study was based on the cognitive radio technology and in previous years the cognitive engine problem is usually solved by genetic algorithm (GA). The related study gives the idea that the GA converges slowly and its performance can still be improved. In this paper, MACO algorithm with excellent performance is applied to the cognitive engine and the simulation results show that the fitness scores obtained by the MACO engine are much better than the ACO and GA engines in different scenarios.

Table 1
List of algorithm worked on QoS Parameters

Survey	*Optimization Algorithm*	*Authors*	*QoS Parameters*	*Publication Year*
[11]	Genetic Algorithm	Newman T.R, Brett A. Barker, Wyglinski, H.M & Arvin Agah	Power consumption, BER, throughput	2007
[12]	Genetic Algorithm	Timothy R. Newman and Joseph B. Evans	Power consumption, Ber, throughput, interference and spectral efficiency	2008
[13]	Binary ant colony optimization	Muhammad Waheed, Anni Cai	Power consumption, ber, data rate	2009
[14]	Particle swarm optimization	Zhijin Zhao, Shiyu Xu, Shilian Zheng, Junna Shang	Power consumption, ber, throughput	2009
[10]	Mutated ant colony optimization	Nan Zhao, Shuying Li, Zhilu Wu	Low power mode, emergency mode, multimedia mode	2011

Survey	Optimization Algorithm	Authors	QoS Parameters	Publication Year
[9]	Adaptive Discrete PSO	Ali Mahdi, Jerome Mohanan, Mohamed A. Kalil, Andreas Mitschele- Thiel	Power consumption, ber, data rate	2012
[15]	Genetic algorithm	Ankit Awasthi, Vipul Awasthi	QoS, RSSI, bandwidth, noise delay	2013
[8]	Simulated Annealing	Kiranjot kaur, Munish Rattan, Manjeet singh patterh	Power consumption, BER, throughput, interference, spectral efficiency	2013
[7]	Adaptive multi objective optimization scheme	Ismail AlQerm, Basem Shihada	Power consumption, ber, throughput, interference, spectral efficiency, delay	2014
[6]	Particle Swarm Optimization technique	Seshadri Binaya Behera, D.D seth	Power consumption, spectral efficiency, SINR	2015

3. COGNITIVE RADIO QOS PARAMETERS

The one of the main issues that has been identified in CR system is "Quality of Services" parameters. The primary users have the license to use the radio spectrum but the secondary users have no license to use the radio spectrum accordingly. The secondary users only use the radio spectrum when it is lying free. So, the QoS parameters have the responsibility to ensure the secondary users communication without interference with the primary users and the more number of users use the radio spectrum.

There are many QoS parameters that has to be satisfied the primary users and secondary users, but in this survey we discuss about five parameters

1. Power consumption
2. Bit error rate
3. Throughput
4. Interference
5. Spectral efficiency

1. **Power Consumption:** The amount of power used by the system should be decreased.

   The fitness function of minimum power consumption is given as:

$$F_{\text{min-power}} = P/P_{\max} \tag{1}$$

   where, P denotes average transmit power and P_{max} is the maximum available transmit power.

2. **Bit Error Rate:** The number of bit error produced in per unit time should be reduced and improve the overall BER of the transmission.

   The fitness function for minimizing bit error rate is

$$F_{\text{min-ber}} = \log10\ (0.5)/\log10\ (P_{be}) \tag{2}$$

   where, P_{be} represents the BER o the modulation type

3. **Throughput:** The rate at which the message is successfully transmitted through the system is termed as throughput.

   The fitness function of maximizing throughput is:

$$F_{\text{max-throughput}} = 1 - \log2\,(M)/\log2\,(M_{max}) \quad (3)$$

where, M is the modulation index of single carrier and M_{max} is the maximum modulation index.

4. **Interference:** Interference must be reduced for better communication

   The fitness function for minimizing interference is given as

$$F_{\text{min-interference}} = \{(P + B + TDD) - (P_{min} + B_{min} + 1)\}/(P_{max} + B_{max} + Rs_{max}) \quad (4)$$

   where, B is bandwidth, B_{min} and B_{max} is the minimum and maximum bandwidth, TDD is the time division duplexing, Rs is the symbol rate and Rs_{max} is maximum symbol rate.

5. **Spectral Efficiency:** The information rate that can be transmitted over a given bandwidth in a particular system should be increased.

   The fitness function of spectral efficiency is given as

$$F_{\text{max-spectral efficiency}} = 1 - (M \times B_{min} \times Rs)/(B \times M_{max} \times Rs_{max}) \quad (5)$$

4. SWARM INTELLIGENCE OPTIMIZATION

The process of using the best inputs and in terms of obtaining the maximum/minimum output with lesser amount is known as optimization. The optimization is normally based on the behaviour of nature (i.e. animals, bacteria's and many more), that's why they termed as swarm intelligence optimization.

Many researchers in their research in CR system use various optimization algorithms and find the results. In our survey we consider few algorithms and discussed about them.

4.1. Ant Colony Optimization

Ant colony optimization is initially introduced by Dorigo and Di Caro [16]. ACO based on the foraging behaviour of real ants. The main objectives of the ants are that they find the shortest path between its food and nest.

4.1.1. Research Scenario

Nan Zhao et. al. [10] first apply ACO algorithm and then after they proposed MACO (mutated ant colony optimization) to find the results. Normally in the previous papers cognitive engine problem was solved by genetic algorithm but they mention that the GA algorithm converges slowly and further they apply MACO to the cognitive engine problem and gets better results.

Muhammad Waheed et. al. [13] use the binary version of ant colony optimization. The researchers compare their results with genetic algorithms and shows that their simulation results are better than genetic algorithm in terms of convergence speed and converged fitness value.

4.2. Particle Swarm Optimization

PSO is first introduced by Kennedy and Russell Eberhart in 1995 [17]. PSO is population based stochastic optimization technique produce on the social behaviour of animals/ insects.

4.2.1. Research Scenario

Tareq M. Shami et. al. [18] uses binary version of particle swarm optimization to solve the cognitive radio optimization problem. The simulation results shows that the viability of using BPSO maximize the sum throughput.

Seshadri Binaya Behera et. al. [6] using PSO to optimize the resource allocation problem.

The simulation results show that with greater number of particles in a swarm along with the number of iterations increases the fitness of the variable.

5. CONCLUSION

As the Cognitive radio is one of the emerging technologies in the present world, so the overall discussion is about to improving the QoS parameters and the authors use algorithms in this field gives certain improving outcomes. The algorithms like ACO, PSO have some features in terms of finding the best outcomes like high convergence speed and in order to solve the complexity of problems.

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