ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 5, Issue 12, June 2016

A Review on QOS Parameters in Cognitive Radio Using Optimization Techniques

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Abstract - Cognitive radio (CR) is an advanced technology in wireless communicationsystems, which allows the use of frequency spectrum efficiently. Proper utilization of frequency spectrum is possible by using dynamic spectrum allocation. The progress of the radio spectrum depends on how efficiently these resources or spectrum are allocated. The CR users or the secondary users are allocated with the unused licenced spectrum available in the white space without causing interference to the licensed primary users. In this paper, the optimization of CR system has been discussed using genetic algorithm (GA) technique. GA is an adaptive heuristic search, based on evolutionary concepts.GA has been used to define the Quality of services (QOS) parameters in terms of minimum bit error rate, maximum throughput, minimum power consumption, minimum interference, maximum spectral efficiency and it has been observed that GA is suitable for user's requirements. Other optimization techniques namely - simulated annealing, Ant colony optimizations arealso discussed in this paper and a comparison of these techniques are discussed.

Keywords: **cognitive radio, Genetic algorithm, quality of service parameters.**

I. INTRODUCTION

The electromagnetic spectrum is responsible for all radio transmission with limited frequency bands. The range of radio spectrum is from 3Hz to 3000GHz. With the rapid growth of large number of users the limited spectrum is expected to cause the scarcity problem, to overcome these problems cognitive radios (CR) is designed.Cognitive radio is a technology which is able to provide solution to the spectrum scarcity problem [1]. Cognitive radio makes use of spectrum with licensed and unlicensed bands. FCC (federal communication) published a report in November 2002, design new spectrum strategies to solve the over-crowding bands [2] and allowing the secondary user to use licensed bands accordingly.

II. COGNITIVE RADIO

CR is one of the latesttechnology in which it has intelligence to automatically sense and learn the surroundings to accommodate the most appropriate user's requirements. Cognitive radio is generally executed with software designed radio (SDR) [3] which enhance machine learning and optimizing algorithms that are capable to modify radio transmission parameters to communication environment conditions. Mitola's vision [4] was to build a cognitive engine for resource management that is capable to sense, detect, judge and act to improve network performance. However, the traditional approach used for allocation of radio spectrum is static or fixed approach. In this approach the secondary users do not have any authority to use the radio spectrum assigned to primary users. This results in underutilization of radio spectrum and makes system work slowly. So in order to overcome this,a new approach called dynamic spectrum allocation (DSA) [5] is considered. Due to this approach secondary users use the frequency bands of primary users without causing any problem. Thus cognitive radios decide the best available spectrum band to meet the quality of service requirements. The optimization techniques can be used to optimize the parameters and make the parameters possible for maximum or minimum values as per user's requirements.
Classification of cognitive radio:

A. Depending on transmission and reception parameters, there are two main types of cognitive radio:

1) Full Cognitive Radio: CR considers all parameters. A wireless network is able to recognize every possible parameter clear.

2) Spectrum-Sensing Cognitive Radio: The channels are detected from the available frequency spectrum.

B. Other types are dependent on parts of the spectrum available for cognitive radio:

3) Licensed-Band Cognitive Radio: These are also known as primary users. In this type only the licensed users have right to use the frequency spectrum. The particular bands have assigned to licensed users such as UNII band or the ISM band.

4) Unlicensed-Band Cognitive Radio: These are also known as secondary users. In this type the users have no licensed to use the frequency band but they can use while the spectrum is lying free.

III. LITERATURE REVIEW

In 2007, Tim R. Newman et al. [6] introduces a genetic algorithm,in which radio parameters given a dynamic wireless channel environment is the primary feature of cognitive radios. Thus CR decision engine determines the optimal radio transmission parameters for single and

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 5, Issue 12, June 2016

multicarrier systems. In this paper the accurate set of single carrier and multicarrier fitness functions for GA implementation occurred and hence the evolutions of algorithm have been derived.

In 2009, Sebastien Herry et al. [7] authors focused on parameters determination of secondary user's cognitive radio using genetic algorithm. In this they investigated a solution to work out parameters of secondary user network that fit into spectrum holes offered by primary user network.

In 2010, Maninder Jeet Kaur et al. [8] focused on various optimization techniques on allocation of spectrums targeting secondary user's, which follows the optimization techniques GA & evaluated and have compared them. They have assumed that the secondary users have already specified the requirement of quality of service and the sensing of the secondary holes have carried out.

In 2011, Nan Zhao et al, [9] proposed a mutated ant colony optimization cognitive radio engine. In this paper ACO algorithm is first time to apply in cognitive radio engine design. The cognitive engine problem is usually solved by genetic algorithm however the GA converges slowly and its performance can still be improved. MACO algorithm with excellent performance is applied to the cognitive engine.

In 2013, Kiranjot Kaur et al, [10] focus on the optimization of cognitive radio using simulated annealing (SA) technique. SA is a stochastic global optimization technique that separate between different local optima. SA has been used to meet the quality of service (QOS) that is defined by users in terms of minimum transit power, minimum bit error rate, maximum throughput, minimum interface and maximum spectral efficiency. In this paper SA is compared with GA and it is concluded that SA algorithm performs better than GA for the cognitive radio system. The number of interaction and time taken by SA to reach the optimized solution are more than GA.

In 2013, Abdelfatah Elarfaoui et al. [11] work on genetic algorithm and propose crossover method. In this the flexibility of genetic algorithm is shown and it can also be used with other metaheuristic to enhance the quality of solution without causing the system complexity and time of execution. In this paper the quality of services parameters is considered and finds the appropriate solution to get the output results.

In 2014, Ismail AlQerm et al. [12] work on adaptive multiobjective optimization scheme in which they considered the transmission parameters to environment conditions using constrained optimization. In this paper they worked on adaptive genetic algorithm in terms of its parameters. The complexity of the system is reduced by using adaptive genetic algorithm and the system works on multiobjective functions.

In 2015, Seshadri Binaya Behera et al. [13] work on particle swarm optimization algorithm to optimize the resource allocation problem. In order to maintained the problem resource allocation the cognitive radio users required some factors such as spectral efficiency, signal to interference noise ratio (SINR), power efficiency etc. which are improved according to user's requirement. The parameters areoptimizing with PSO and to improve the spectrum utilization. In this paper [10] the author compares PSO with GA and after comparing the output can be produced with reduced computational complexity.

IV. OPTIMIZATION TECHNIQUES

A. Genetic algorithm

The genetic algorithm based on the fact that the measure of success of an individual is its fitness i.e. "survival of fittest". It states that the best combination of genes and their resulting chromosomes yields the strongest individual, which will survive the longest. Therefore, GA is adaptive heuristic search based on evolutionary concepts. Genetic algorithms are typically used as a method of problem optimization and due to its random nature, fast convergence time and ability to spontaneously generate unique solutions. Thus, genetic algorithms are an appealing candidate for cognitive radios. Genetic algorithms are used mainly when the search space is too large to be simply brute force search to determine the optimal parameters.

Advantages of GA over traditional algorithms are

- Computational complexity handling capability.
- It deals with all objective functions whether they are stationary or transient, continuous or discontinuous.

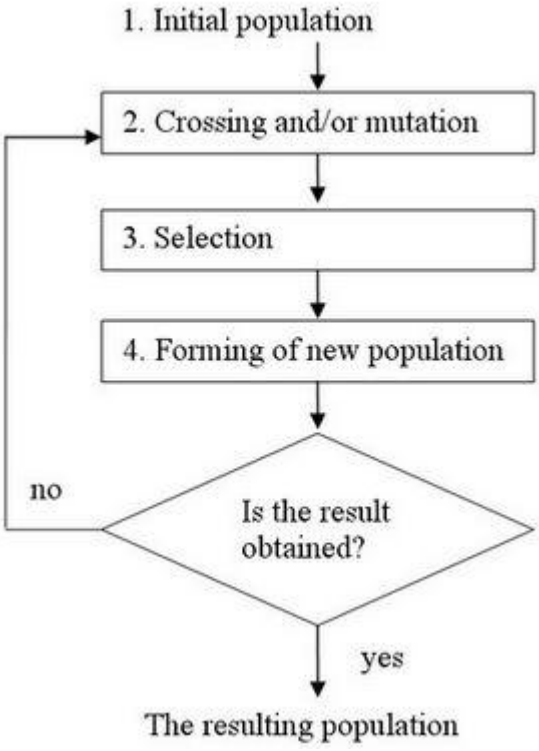

Fig 1: flowchart of genetic algorithm

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 5, Issue 12, June 2016

B. Ant colony optimization

ACO meta-heuristics is one such technique that is based on the cooperative foraging strategy of real ants. In this approach, several artificial ants perform a sequence of operations iteratively. Within each iteration, several ants search in parallel for good solutions in the solution space. One or more ants are allowed to execute a move iteratively, leaving behind a pheromone trial for others to follow. An ant traces out a single path, probabilistically selecting only one element at a time, until an entire solution vector is obtained.

C. Simulated Annealing

Simulated Annealing algorithm is a general purpose optimization technique and has been applied to many combinatorial optimization problems. The main idea behind SA is an analogy with the way in which liquids freeze and crystallize. When the liquids are at high temperature their molecules can move freely in relation to each other. As the liquid's temperature is lowered, this freedom of movement is lost and the liquid begins to solidify. If the liquid is cooled slowly enough, the molecules may become arranged in a crystallize structure. If the liquids is cooled very rapidly it does not form such a crystallize structure, but instead forms a solids whose molecules will not be in a minimum energy state. Thus, SA aims to achieve a global optimum by slowly convergence to a final solution.

V. COGNITIVE RADIO PARAMETERS AND OBJECTIVES

Cognitive radio is able to interact with the environment and this can help to maintain the appropriate communication parameters in order to adjust as the dynamic radio spectrum. The parameters can be decided how communications can be occur with less interventions and large number of users can accommodate in radio spectrum.

a. Transmission parameters

Transmission parameter makes the decision for cognitive radio system to which it can communicate. The transmission parameters can decide to where the information can be transmitted and how they are communicated.These transmission parameters must be well defined before the fitness function is developed by the user. Table 1 shows the list of transmission parameters used.

TABLE 1: Transmission parameters

PARAMETER NAME	DESCRIPTION
Transmit power	Raw transmission power
Modulation type	Type of modulated format
Modulation level	No. of symbol used for a given scenario
Symbol rate	No. of symbol per second
Packet size	Size of the packet used for transmission

b. Environmental parameters

These parameters give knowledge to the cognitive radio system on the surrounding environment conditions. The sensed information through the surrounding helps the cognitive controller on making decisions. The three common environmental parameters used are bit error rate (BER), signal to noise ratio (SNR), noise power (N).

c. Cognitive radio objectives

There are different desirable objectives that a radio system may want to achieve in wireless communications environments. With these desired objectives the cognitive radios work well and it suits the user's requirements. The large number of users can use the frequency spectrum after fulfilment the following objectives criteria. Table 2 describe the following cognitive objective used in the work.

TABLE 2: Cognitive radio objectives

OBJECTIVES	DESCRIPTION
Minimize bit error rate	Utilize spectrum with minimum errors
Maximization of throughput	Maximize the user's data transmission
Minimization of power consumption	Maximize efficiency by consuming less power.
Minimization of interference	Less no. of interferences
Maximization of spectral efficiency	Frequency spectrum is used more efficiently

VI. MULTI OBJECTIVE OPTIMIZATION IN COGNITIVERADIO

Multi objective function has been considered to optimize the cognitive radio. The parameters has been decided in such a way that we use best user's output.

1. Minimization of bit error rate (B.E.R)

BER is used to find the quality of each link in terms of number of bit errors per unit time. The information which are transmitted in the system contains less number of error due to this complexity of the system isreduced whileminimizing errors. Thus the fitness function is decided to minimize the BER i.e.

$$F_{\text{min-ber}} = \log10\ (0.5)/\log10\ (P_{be}) \qquad (1)$$

Where, Pbe represents the BER of modulation type being used. Therefore, the optimization techniques like GA, SA, and ACO are applied to find the minimum bit error rate. The numbers of iteration are applied by the techniques to get the minimum bit error rate.

2. Maximization of throughput

Throughput is another important optimization objective in certain objectives like multimedia and computer applications. Thus, throughput is total rate at which something can be produced. With this throughput after maximizing, the large of information are produced. Thus fitness function is obtained to optimize the maximization of throughput.

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 5, Issue 12, June 2016

$F_{max\text{-}throughput}$= 1-log2 (M)/log2 ($M_{max}$) (2)

Where M is modulation index of a single carrier and Mmax is the maximum modulation index. The optimization techniques are applied to get the maximum throughput and this is achieved after performing no. of iterations.

3. Minimization of power consumption

The life of battery usage and power consumed are important factors for reducing power consumptions. The fitness function is obtained to optimize the minimization of power consumption.

$F_{min\text{-}power}= P/P_{max}$ (3)

Where P is average transmit power, Pmax is maximum available transmit power.

4. Minimization of interference

Interference is main problem occurred in CR due to the shared spectrum environments. Interference is main priority that secondary user's cannot collapse with primary user's while use in the system.

The fitness function is obtained to optimize the minimization of interference.

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

Where B= bandwidth required for single carrier, Bmin and Bmax is minimum and maximum bandwidth available, TDD is time division duplexing, RS_{max}=max. Symbol rate. The genetic algorithm has been applied to optimize the minimization of interference.

5. Maximization of spectral efficiency

Spectral efficiency is the total amount of information that is transmitted over a given bandwidth.

The fitness function to maximize spectral efficiency is expressed as:

$F_{max\text{-}spectraleff}= 1-(M*B_{min}*Rs)/(B*Mmax*Rsmax)$(5)

Therefore optimization technique can be applied to optimize the spectral efficiency with the optimization the large no. of information can be transmitted with the limited bandwidth.GA is applied to maximize the spectral efficiency and hence achieved after performing number of iterations. Hence, to derive the objective function for this optimization problem in cognitive radio, the weighted sum approach is used, because it provides a convenient process for applying weights to the objective. The weight vector is applied to fitness function because all the parameters run simultaneously and get their values, so in order to overcome the system complexity the weight vectors are applied.

$F_{sum}= w1*(F_{min\text{-}BER}) + w2*(F_{max\text{-}throughput}) +w3*(F_{min\text{-}power}) +w4*(F_{min\text{-}interference}) +w5*(F_{max\text{-}spectral\ efficiency})$ (6)

The above equation (6) shows the overall fitness function with weighted vectors. These weights evaluate the each fitness function given in the equation.

VII. RESULT ANALYSIS

TABLE 3: Cognitive engine implementation for wireless multicarrier transceivers (2007) [6].

Scenario	G.A(Genetic algorithm) Converged fitness
Low power mode(minimum power consumption)	0.930
Emergency mode (minimum B.E.R)	0.800
Multimedia mode (maximum throughput)	0.938

In the above table 3 the fitness of system produced by Genetic algorithm and the values considered is best fittest value which produced the results.

TABLE 4: Genetic algorithm application in optimizing transmission parameters on adaptive mechanism of cognitive radio (2009) [14].

Scenario	G.A (Genetic algorithm)
Minimum transmit power	0.927174
Minimum B.E.R	0.852842
Maximum throughput	0.952603

TABLE 5: Cognitive engine design based on ant colony optimization (2012) [9].

Scenario	GA	ACO	MACO
Low power mode	0.9383	0.9107	0.9482
Emergency mode	0.8422	0.8485	0.8523
Multimedia mode	0.9395	0.9416	0.8460

In the table 5 the comparison table of GA, ACO and MACO is considered and after comparing GA produces the best results and this is compare with less number of iterations.

TABLE 6: Optimization of cognitive radio system using simulated annealing (2013) [10].

Scenario	GA	SA
Minimum power	0.054708	0.036618
Minimum B.E.R	0.086745	0.070041
Maximum throughput	0.043464	0.02380

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 5, Issue 12, June 2016

Minimum interference	0.078572	0.049242
Maximum spectral efficiency	0.038027	0.019472

Therefore, after analyses it is clear that genetic algorithm is regarded as universal technique and considered mostly. Thus, it provides more accuracy and efficiency. The complexity of the system can be reduced with genetic algorithm.The above results show that Genetic algorithm is used in most of the cases in terms of best fitness score and sometimes considered with less numbers of iterations.

VIII. CONCLUSION

This paper presents the optimization of quality of service parameters of cognitive radio using Genetic algorithm technique.Thus, GA reduces the system computational complexity and it is fast in convergence. The GA is produces best fitness scores with less number of iterations as compare to other optimization techniques.The secondary users are able to use the primary user's frequency bands and this is possible because of proper utilization of frequency spectrum. In cognitive radio large numbers of user's make the wireless communication overcrowded and by using dynamic spectrum allocation approach the problem of spectrum scarcity is reduced. Different transmissions of CR system have been optimized to satisfy various objectives under environmental constraints. The optimization techniques can be used to optimize the QOS parameters in order to get the local maxima or local minima.

IX. FUTURE WORK

With the over usage of electronics applications day by day the spectrum utilization is become important. So proper usage of frequency spectrum some parameters are also considered in future such as proper power allocation, data rate, frequency bands.

REFERENCES

[1] S.Srinivasa and S.Jafar, "cognitive radios for dynamic spectrum access-the throughput potential of cognitive radio: A theoretical perspective", IEEE communication Magazine, vol.45, pp.73-79, May 2007.

[2] Federal communication commission, "spectrum policy task force", Report of ET Docket 02-135, 2002.

[3] Petri Mahonen, Marina Petrova, Janne Riihijarvi and Matthias Wellens, "Cognitive Wireless Networks: Your Network Just Became a Teenager", in Proceedings of IEEE INFOCOM 2006, 2006.

[4] J. Mitola III, "cognitive radio: An integrated Agent Architecture for Software Radio", PhD thesis, Royal institute of Technology (KTH), 2000.

[5] C. Rieser "Biologically inspired cognitive radio engine model utilizing distributed genetic algorithms for secure and robust wireless communications and networking", PhD thesis, Virginia Tech, 2004.

[6] Tim R. Newman, Brett A. Barker, Alexander M. Wyglinski, Arvin Agah, Joseph B. Evans and Gary J. Minden, " cognitive engine implementation for wireless multicarrier transceivers", Wiley Wireless communications and mobile computing, 7(9), 1129-1142 (2007).

[7] Sebastian Herry and Christophe J.Le Martret, "parameter determination of secondary user cognitive radio network using genetic algorithm", IEEE 2009.

[8] Maninder Jeet Kaur, Moin Uddin, Harsh K.Verma, "Performance Evaluation of QoS parameters in cognitive radio using Genetic Algorithms", In World Academy of Science, Engineering & Technology, vol.4, No.10, pp.830-835, 2010.

[9] Nan Zhao, Shuying Li, Zhilu Wu, " cognitive radio engine design based on Ant colony optimization", Wireless pers communication, 2012.

[10] Kiranjot kaur, Munish Rattan, Manjeet Singh Patterh, "optimization of cognitive radio system using simulated annealing", wireless pers communication, 2013.

[11] Abdelfatah Elarfaoui, Noureddine Elalami, "optimization of QOS parameters in cognitive radio using combination of two crossover methods in genetic algorithm", Int. J. Communications, network and system sciences, pp. 478-483, November 2013.

[12] Ismail AlQerm and Basem Shihada, "Adaptive multiobjective optimization scheme for cognitive radio resource management", Globecom 2014.

[13] Seshadri Binaya Behera, D.D.Seth, "Resource allocation for cognitive radio network using particle swarm optimization", IEEE sponsored 2'nd international conference on electronics and communication system (ICECS '2015').

[14] Ang. T. J, "Genetic algorithm application in optimizing transmission parameters on adaptive mechanism of cognitive radio", project report, Universiti Teknologi Malaysia (2009).

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