Genetic Optimization for Dynamic Spectrum Sharing in Cognitive Radio Networks in Interweave Mode

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Abstract: Dynamic spectrum sharing among the wireless users is growing demand to increase the spectrum usage. In this paper, , based upon a pricing strategy to overcome the drawbacks of the traditional mechanisms. The proposed mechanism enhances the spectral efficiency of the cognitive users and also motivates the primary users to lease the bands to the cognitive users, with increased primary user revenue. Fairness among cognitive users is also ensured in this mechanism. . Simulation results show that our mechanism increases the spectral efficiency of cognitive users and the revenue of primary users.

Keywords: Cognitive Radio, Dynamic spectrum access,VCG, Auction mechanism, Second price auction, Multi-winner auction

1 Introduction

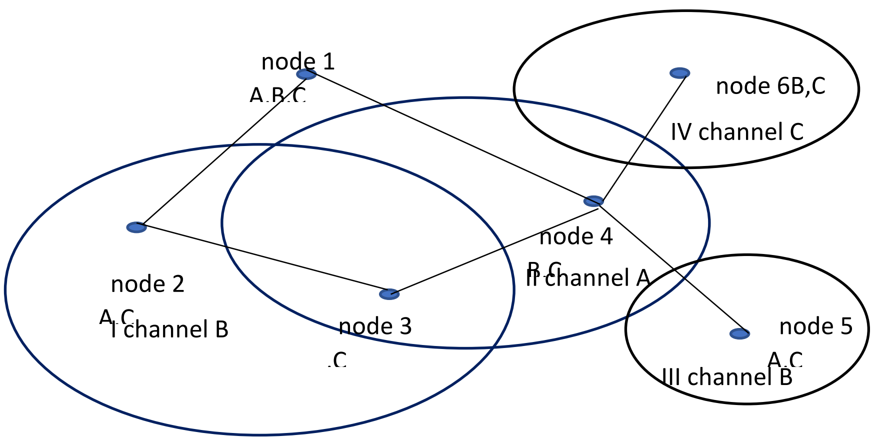
In order to meet the growing demand for spectrum usage different services require different spectrum bands,For example if we take Aeroplane it works in the frequency range(108-137 MHz) and Satellite Communication works in range of (20-30 GHz), Mobiles works in the frequency range of (225-3700 MHz) and Dish works in the frequency range of (950-2150 MHz).There is also increase in the number of Cell phone users globally around 2 Billion users across the world. this growing demand for spectrum usage make more and more people subscribe to one or many of the wireless services.This growing demand for wireless users increase the demand for additional bandwidth. In the curent spectrum allocation policies the frequency bands are statistically assigned to specific wireless operators/services. frequency allocation policies lead to a low utilization of licensed frequency spectrum.for example ,in most of the time only 6% of the frequency spectrum is active and remaining part of the spectrum is not active or not used by the wireless users.Cognitive Radio is a Transceiver model which senses the vacant unused channels and make use of it for its communiation. in this paper we have designed a cognitive radio system model based on overlay spectrum sharing modes. In overlay spectrum sharing mode the cognitive radios overhear and enhance the primary user’s transmissions.The spectrum allocation among the secondary users is olved by bargaining game and the spectrum price is set by bertrand game [1]. the spectrum access is formulated as a Reward based game based on recursive double threshold structure.the users will compare the channel stastistics with those thresholds sequentially to decide their actions[2].A belief directed game [3] is formulated with the players negiotate naturally through a sequence of calculated competition.In order to address multiple objectives in finding the best spectrum allocation based on parameters like BER, Power Consumption and Interference. in this work we have proposed a Multi Objective Genetic Optimization Algorithm with multiple constarints including the pareto fonts. the main reason to choose this algorithm is that the Genetic Algorithm reduce the entire space in less time without compromising on throughput for spectrum utilization problem. the throughput here refers to finding the spectrum band and using the spectrum band more efficiently.

The paper is organized as follows; Section II gives the Channel allocation model framework. Section III provides the introduction to Genetic algorithm and the existing Brute force Algorithm. Section IV gives the modified scheme in detail, section V gives the simulation results and discussion, section VI gives the conclusion and future work.

2 System Model

2.1 Distributive Spectrum sharing model:

The dynamic spectrum sharing among cognitive users is based on the prediction of the Primary user’s arrival at different channels in interweave mode. The best channel for communication to the secondary users is based on the primary user activity. The Genetic Algorithm (GA) solve the problem of searching large space in low execution time with best outcome and it also have least probability of struck in local extremes as compared to other techniques[ga1][ga2]. the main advantage to choose this GA algorithm is parallelism which will enhance the simulation. The system is designed based on terms of chromosomes. The chromosome is random generated binary array strings which is composed of RF parameters as genes. channel model is also encapsulated within the chromosome. The GA selects the fittest set of RF parameters for finding the optimal communication in RF Environment.



the figure1 shows the system model with I,II,III,IV refers to the primary users and node 1 to 6 represents the secondary users.

User 1	**1**	**1**	**0**	**1**	**0**	**0**
User 2	1	1	1	0	0	0
User 3	0	1	1	1	0	0
User 4	1	0	1	1	1	1
User 5	0	0	0	1	1	0
User 6	0	0	0	1	0	1

(a)

A	B	C
1	1	1
1	0	1
0	0	1
0	1	1
1	0	1
0	1	1

(b)

Figure 2 (a) shows the Channel Assignment Policy Matrix S. Fig 2(b) shows the Channel Availability Matrix

2.1.1. Formulation of the spectrum allocation matrix:

As shown in the figure 2 the spectrum allocation matrix is formulated with additional constraints namely interference graph and channel availability. The edges formed between the two neighboring users is represented as E.

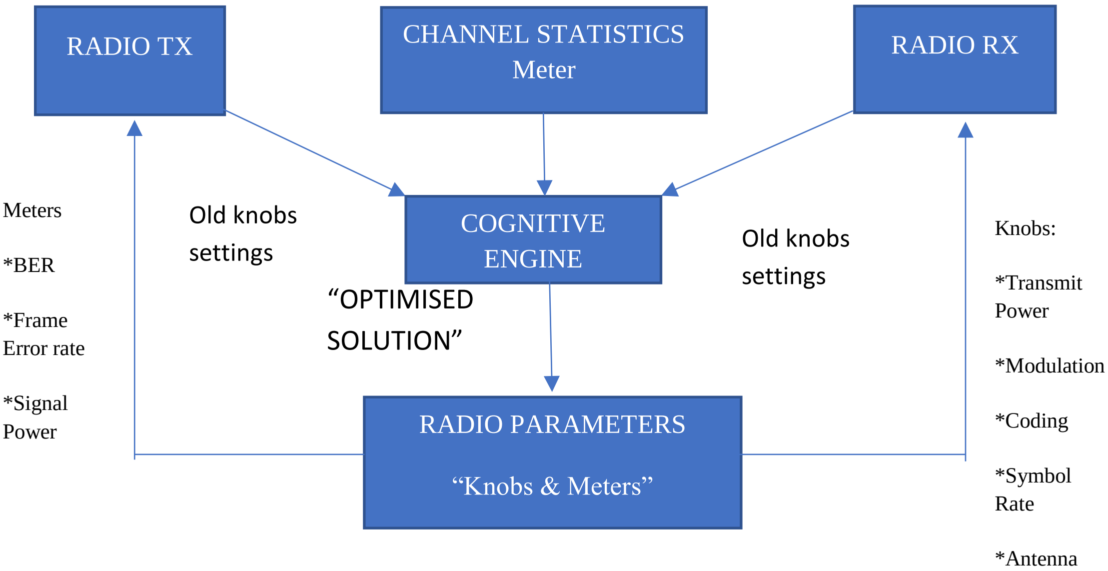
where E=e_{ij} e_{ij} =1 user i and user j have there edges formed .

when e_{ij} =0 means that user i and user j both use the same channel.

The channel can be assigned to the user only if it available at the node.

- S_{ik} = 0 if l_{ik} = 0 which means a channel can be assigned to the user only if it is available at that node.
- when $C_{i,j,k} = 1$, if users i and j will experience interference if they use same spectrum band k.
- Considering the spectrum allocation matrix S = S_{ik}
- N × K which denotes the effectiveness of spectrum allocation, where S_{ik} = 1 denotes that spectrum band k is assigned to user n.

$$S_{ik}S_{jk}e_{ij} = 0 \ ¥\, \mathrm{i, j} = 1 \ldots \mathrm{N, K.}$$
$$C_{i,j,k}|C_{i,j,k} \in \{0,1\}N \times N \times K,$$



CR Reads the Meters and turns the Knobs

Fig shows the cognitive engine in CRN Architecture

Cognitive engine is the Central proceesing unit for the Cognitive radio networks.Inputs to the cognitive engine is from the transmitter and receiver with channel statistics. The data fusion in this cognitive engine provides the optimised solution to design further process the information about the secondary user.The distributed secondary users make use of this available information from the cognitive engine.After receiving the information from the cognitive engine tuning the knobs and meters is done for further use of primary user spectrum. The knob adjustments are Tranmsit Power,Modulation Technique,Coding,Symbol Rate,Antenna type.The Meters adjustments are Bit error rate,frame error rate, signal power.These adjustment values are prefixed in our genetic optimization as binary chromosome structure which are fetched as inputs to the Optimizer the Genetic Optimizer finds the best spectrum secondary user for Spectrum Allocation.

3 Genetic Algorithm

In this section, genetic algorithm is used to find the best spectrum allocation for multiple objectives as constraints.Genetic algorithm works with many steps in consideration. they

Algorithm for Genetic Algorithm:

Step1. Initial population with randomly generated binary encoded strings.
Step 2. Set the Population size.
Step 3. Select the Random Secondary users with maximum bandwidth and formulate the fitness function.
Step 4. Roulette wheel-based selection is used to choose the fitness function.
Step 5. Crossover the fitness function at a rate of 0.6
Step 6. Apply Mutation (0.001) to the fitness function after crossover and obtain the offspring.
Step 7. Select the offspring's based on high fitness value and again insert it in the initial population for generating new population set.
Step 8. Repeat the steps again for n times until maximum fitness value.

3.1 Step 1:

we have generated binary encoded strings where each string is a combination of many chromosomes. each chromosome is a combination of genes. Each gene corresponds to specific RF Parameter in RF environment. The list of RF Parameters is

(1) Operating Frequency Band (FB)
(2) modulation Technique
(3) BER
(4) Data rate
(5) power transmitted
(6) interference to the primary user (ITPU)
(7) Transmission to Opportunity.

In Cognitive radio network the channel selection and parameter adaptation play a main role. In order to meet the best quality of service with respect to data rate and service time and channel switching and minimum interference a new gene is inserted in the chromosome structure known as transmission opportunity index (TOI). This TOI gene will reduce the power for transmission by reducing the number of retransmissions to Primary user.

3.1.1 Step 2 :

Initilize the population size and the RF input parametes as a binary array string with the string length is based on the number of the secondary users.

i)Minimize the power consumption:

$$f_{\min\_power} = 1 - \frac{\sum_{i=1}^{N} P_i}{N * P_{max}}$$

ii) Minimize Bit Error Rate:

$$f_{\min\_ber} = 1 - \frac{log_{10}(0.5)}{log_{10} P_{be}}$$

iii) Maximize Data Throughput:

$$f_{\max\_throughput} = \frac{log_2 M}{log_2 M_{max}}$$

3.1.2 Step 3:

Select the secondary user with maximum fitness value if it satisfies the system criterian choose it as a offspring to the next new generation. If the selected secondary user doesnt satisfy the system criterian then the secondary user is crossover and mutated again to meet the maximum fitness value. if the new off spring after mutation meets the system criteris it is included in the new genration if not it is thrown out of the system model and again randomly choose the new chromosome for finding the maximum fitness value.

iv) Weighted Sum Objective Function:

$$f = w_1 * f_{\min\_power} + w_2 * f_{\min\_ber} + w_3 * f_{max\_throughput}$$

$$subject\ to\ w_1 + w_2 + w_3 = 1$$

3.1.3 Step 4: Apply Crossover To The Fitness Function:

The reproduced strings generated from the combination of substring mating pool are randomly performed under crossover operation [14].The methodology used in crossover technique in our proposed paper approach is the conflict-based crossover.

3.1.4 Step 5: Apply Mutation to Conflict Users Randomly:

The conflict channel is choose based on the separation function applied to the Conflict-Based Mutation (CBM). This approach consists of two consecutive steps namely,

- 1) the user is selected randomly based on the available conflict users.
- 2) the user with high band value is selected as the user with the maximum channel bands[22].

3.2 Brute force algorithm:

The brute force algorithm solves any problem in simplest way.It generates the entire solution set and picks the best set satisfying the system criteria. this brute force algorithm provides the optimal solution with low efficiency.
In order to find the best set C among the possible combination set P the brute force algorithm have two steps namely:
1.Select a valid user among the possible combination set randomly based on the constraints enforced in the system model.
Valid(P,C) and check whether candidate C is a solution for P.
2.The next procedure is to find that the selected best set is the only solution to find the best set from the combination set.
Output(P,C), use the best set C from P as the best choice to the channel allocation.
Step 2 must also conclude that there is no best choice from P after choosing C.for example, for an instance P after choosing the best set C in the current combination set return a null set with data value ^ which shows the distinct from any other sets in combination set.

4 Simulation Results

- The Proposed genetic algorithm selects the optimal set of RF parameters for communication over Cognitive Radio Network [28].
- Every user is assigned one channel from every neighboring primary user in the format of uniform cost function.

Simulation Parameters:

- Power range=[-8 to 24]db.
- Bandwidth=[2Hz-38Hz]
- Tdd=[25-200]
- Population size=[50-200]
- Chromosomes=30 bits

- Generations=[1000-5000]
- Probability of crossover=0.60
- Probability of mutation=0.001
- Elapsed time is 0.101948 seconds even less than 0.2 seconds

In the figure 3,We have simulated the system model for the genetic optimization algorithm where the inputs are choosen based upon the interference and power constraints matrix formulation technique. the user which satisfies this criterian is choosed and the selected best set is given the random binary codes for formulating the chromosome structure to the genetic optimizer. This binary string codes is checked based on fitness function.

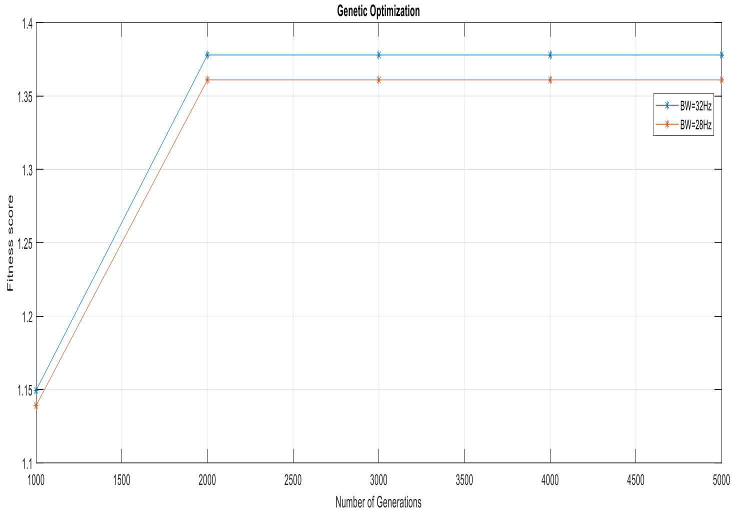


Figure 9. shows the fitness score with number of generations

from the figure 9 , we can conclude that the genetic optimization has better performance on fitness score measure . the fitness value is increasing based on the bandwidth requirement. when there is increase in bandwidth there is increase in fitness score .But the fitness score remains stable over a generations from [2000-5000].where we conclude that increase in genrations has no effect on the performance of the genetic optimizer ,which was able to reach the stable point during the intial simulation process itself. by which the power is drastically reduced by this approach.

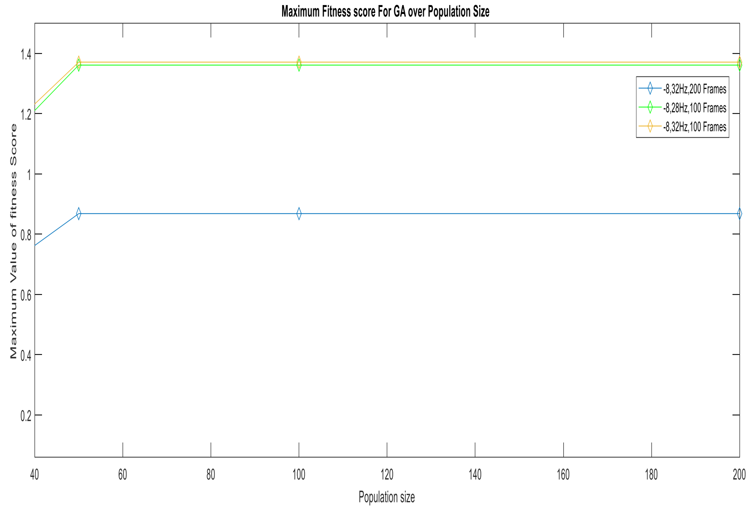


fig 10. Maximum fitness score with increase in teh population size from [40-200].

From this figure 10 ,we can conclude that the fitness score reaches maximum value and comes to a stable point even when there is change in the population size form [40-200].

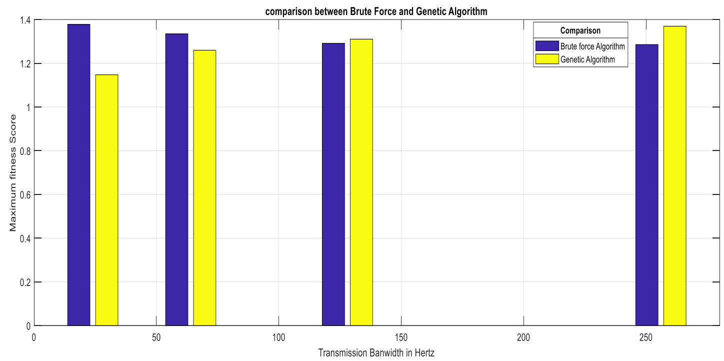


fig 11. Comparison of the Brute force Algorithm and Genetic Algorithm

From the figure 11, we have compared the proposed with the existing Brute force algorithm and we came to conlcusioneven if there is increase in the bandwidth the Genetic optimizer holds a gradual increase . But the existing mechanism doesnt hold good for increase in the bandwidth.

5 Conclusion and Future Work

In this work we have modelled a cognitive engine using genetic optimizer. This genetic optimizer distributes the users and generates a channel availability to find the best channel allocation. Our future work is to test the performance of the Cognitive Radio in Dynamic Spectrum Sharing.

Declarations:

There is no funding ,No conflict of interest,Availability of data and material is not applicable for this proposal.Code availability is also not applicable.

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