# Spectrum Selection in 5G Using GA and PSO

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***Abstract*— Spectrum sharing is considered as a critical mechanism in 5G.This paper is used to satisfy the spectrum scarcity issue, to achieve high data rate access, to provide guaranteed quality-of-service (QoS) and to increase revenue by accommodating more number of user. The interference caused by all secondary users (SUs) should be minimized hence we can achieve the high quality of service.**

***Keywords—Channel allocation,optimization,Heterogeneous network.***

## I. Introduction (*Heading 1*)

The last decade has seen the dramatic increase in the demand of mobile data due to the increase in mobile devices and versatile applications. The data traffic will increase 10-fold between 2014 and 2019. This explosive demand of mobile data results in several challenges which shifted the research directions to fifth generation (5G) networks. 5G networks are used to provide significantly high data rate access and guaranteed quality-of-service (QoS) . Different views on 5G architecture are present with key technologies such as massive MIMO, energy efficient communications, cognitive radios, visible light communication, small cells, etc. The 5G heterogeneous networks will mainly consist of network densification, i.e., densification over space and frequency. The dense deployment of small cells is called the densification over space whereas utilizing radio spectrum in diverse bands is called densification over frequency. Network densification can meet the demand of high capacity in 5G networks. Spectrum sharing ensures the coverage of 5G heterogeneous networks can support a large number of connected devices and diverse applications. In addition, it is spectrum efficient as it can use all non-contiguous spectrum, can achieve better system capacity, reduce energy consumption, and increase cell throughput.

Dynamic spectrum access (DSA) has emerged as key for spectrum sharing in an opportunistic way.

A radio network employing DSA to coexist with a licensed network (primary network) is known as a cognitive radio network (CRN) .The users who subscribe to any of these primary networks are known as primary users (PUs) and other users are called secondary users(SUs). SUs may face a problem in choosing which primary network to join because a 5G heterogeneous network incorporates multiple primary networks with different characteristics in terms of bandwidth, price, and capacity; this is known as the network selection problem. Price is a key factor while leasing/selecting the network of a specific operator for spectrum access.

## II. PARTICLE SWARM OPTIMIZATION

PSO consists of a swarm of particles in which each particle resides at a position in the search space. The position of each particle is represented by a vector. The algorithmic flow of PSO technique starts with an initial population of n random particles. Each particle is initialized with a random position and velocity in the search space. Position and velocity of each particle is updated in every iteration . After the update, the fitness value of each particle is computed using a fitness function. The fitness of each particle represents the quality of its position. The velocity of each particle is influenced by its own best previous position (pbest) and the best previous position (nbest) found by its neighbors. If all the particles in a swarm are defined as neighbors of a particle, nbest is called global best (gbest), whereas if only some of the particles are declared neighbors of a particle, nbest is called local best (lbest).

**Algorithm 1: General description of PSO**

1: Randomly initialize the position $x_k$ and velocity $v_k$ of each $k^{th}$ particle.
2: Calculate the fitness of $k^{th}$ particle.
3: Calculate $pbest_k$ for $k^{th}$ particle.
4: Calculate $nbest_k$ for the swarm.
5: Update the velocity $v_k$ of $k_{th}$ particle .
6: Update the position $x_k$ of $k^{th}$ particle .
7: Calculate fitness of $k^{th}$ particle.
8: Update $pbest_k$ of $k^{th}$ particle.
9: Update $gbest_k$ of the swarm.
10: Terminate the algorithm if the stopping condition is reached, otherwise go to step5.

### *A. Encoding*

Encoding is one-to-one mapping between the solution and the particle. Each particle should consist of a complete solution for SUs, primary networks and channels. This paper considers the $k^{th}$ particle position in a search space of a vector for the problem of M (SUs) and N (PUs), each with $p_m$ channels. Consider an example with parameters N = 5 and M = 5 ,which means that there are five primary networks with five SUs in a 5G heterogeneous network. It is assumed that each $m^{th}$ network has the same channel denoted by p, i.e., $p_m$ = p = 7. In this case, each group of 35 slots (M * p) represents the network and channel allocation for one SU. Slots 1-35 represent both the channel and network allocated for the first

SU, slots 36-70 for the second SU and so on.The M-dimensional position of the k$^{th}$ particle is defined as $x_k = (x_{k1}; x_{k2};$ ::::; xkm).The network and channel corresponding to an element of a particle can be computed as follows:

$$\text{Network} = \frac{x_{kj} - (j-1) * N *}{p}$$

$$\text{Channel} = x_{kj} - p[x_{kj} / p]$$

*B. Fitness Function*

The overall interference incurred by SUs and the overall cost of SUs have to pay (Q(x)). In our case, the fitness function is the inverse of Q(X), which means a solution with higher accumulative interference and subscription charges will have a lower fitness value.

$$\text{Fitness } [k] = (Q(X))^{-1}$$

*C. Update of Velocity and Position*

Here we have to update the position and velocity at each interval. We define the velocity vector of particle k as $v_k = (v_{k1}; v_{k2};$ :::; $v_{kM})$ . Because the values in the particle are slot numbers, a non integer value. The value of each component can be clamped to the range $[-v_{max}; +v_{max}]$ to prevent excessive roaming of particles outside the search area.

*D. Repair Process*

we adopt a repair process where the position of SUs is adjusted to meet the constraints. The first step is to identify infeasibility. There are four types of infeasibility: 1)two SUs clash in terms of their allocation, 2) SU's demand is more than the capacity of the assigned channel, 3) a SU cannot be assigned to this network because it is not willing to pay the charges of this network, and 4) the network cannot accommodate any further assigned SUs because its interference tolerance limit has been reached .The second step is to regenerate the new velocity of the SU to identify a new position (slot) for reallocation.

## III. GENETIC ALGORITHM

Normally GA starts by creating an initial population of chromosomes denoted by Npop. Generic operations are applied during each iteration in order to search for potentially better solutions. The quality of the population may be improved after each generation.

*A. Encoding of Chromosomes*

Chromosomes are the basic building blocks of the GA .Each chromosome should provides complete information about the solution of problem . A chromosome consists of genes that can be represented in the form of a binary or integer string .Once we decide the number of genes for the chromosome next step is encoding the chromosome. Every gene represents the secondary user(SUs)and the SUs should assigned to a network and a channel. We need three bits for representing channel and three bits for network totally six bits.

*B. Fitness measure*

The next step is evaluate the chromosome by measuring it fitness. Fitness measure is also known as survival measure. It determines how well a chromosome will solves the given problem .Fitness value must be a real number, if the value is higher closer will be the chromosome.

*C. Selection of chromosome*

This process will depend on the fitness measure of the chromosome .In this process , population is first sorted by a comparision of fitness value.

*D. Crossover process*

It is also called as reproduction , a pair of parent chromosome are crossed with each other to form a pair of child chromosome . Cross over rate is taken as 0.5.There are different types of crossover mechanism, they are: single point ,two point, multi point and uniform crossover .In this paper, we are using the two point crossover mechanism. It defines that the every bit in the cross points are swapped between the parent chromosome, it will gives raise to two child chromosome. This child will replace the two chromosome from the bottom of the population that are not in the mating pool. It will continues until all chromosome are not in mating pool are replaced .

*E. Mutation:*

It is the reparing process which is applied on the child. The binary values are altered from 0 to1 or vice versa. Number of chromosome undergoing mutation process out of 100 chromosome is specified by mutation rate. This rate is choosen as 0.03(3%).

*F. Elitism:*

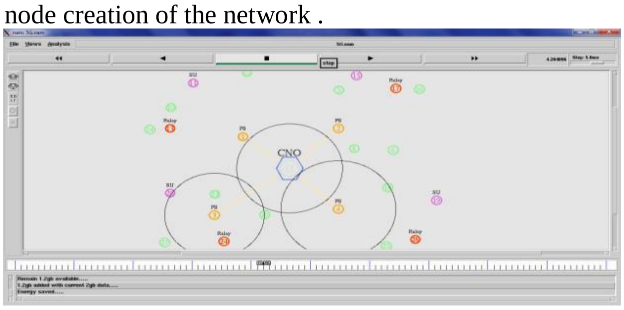
Using the elitism, the best individuals can be preserved from being lost during the process of selection, crossover and mutation.

**Algorithm 2 Elitism based Genetic Algorithm (GA)**

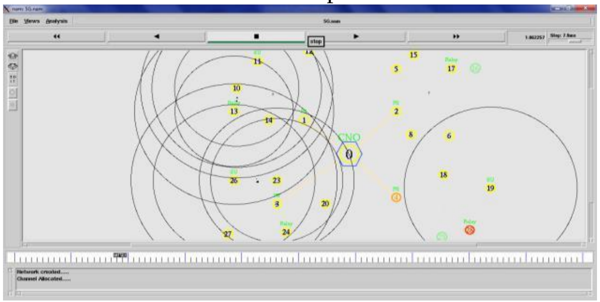
1:Generate the initial population of chromosomes
2: Evaluate the fitness of each chromosome
3: Check for Termination if the stopping condition is reached go to step 4 otherwise step 5
4: Select the best chromosome and Stop
5: Elitist population to preserve the best individual of each generation using sorting mechanism
6: Apply crossover on selected chromosomes
7: Apply mutation on selected chromosomes
8: Go to step 3

## SIMULATION AND RESULT

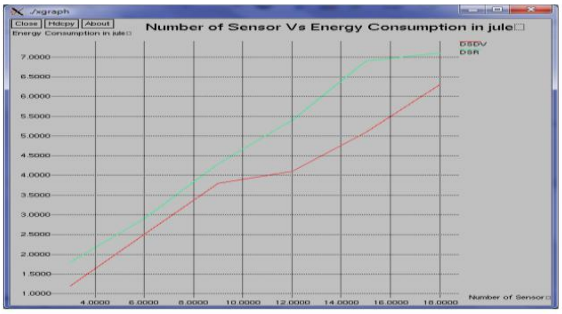
Simulations are carried out for the network selection in 5G heterogeneous network in order to evaluate the quality of the solution and the convergence speed of both PSO and GA algorithms. The performance of both GA and PSO depends on the parameters chosen. The below output shows the node creation of the network .

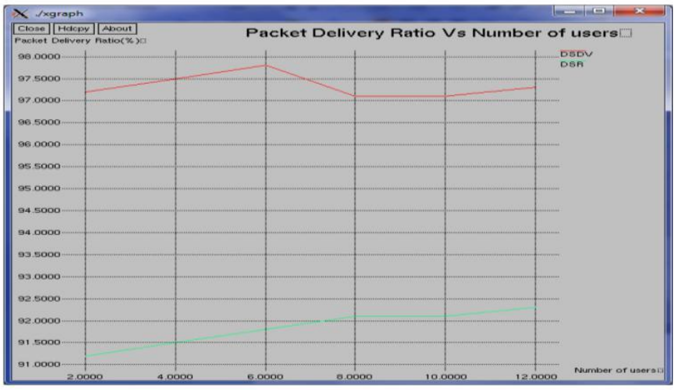


This following picture represents the channel allocation for each users. It also denotes the packet transformation.



The simulations are performed under two scenarios using different data sets in order to compare the performance of GA and PSO. A channel occupied by PU is considered to be unavailable for SUs, therefore, if an SU tries to access this particular channel, the repair process will be triggered. When a SU enters in the system, it specifies its requirements for data rate and the price it is willing to pay to the CNO.




| Iterations | Scenario1 | | Scenario 2 | |
|---|---|---|---|---|
| | GA | PSO | GA | PSO |
| 100 | 0.001623 | 0.0014437 | 0.001646 | 0.001601 |
| 500 | 0.001769 | 0.0014736 | 0.001691 | 0.001626 |
| 1000 | 0.001783 | 0.0014968 | 0.001701 | 0.001634 |
| 1500 | 0.001795 | 0.0015050 | 0.001708 | 0.001642 |
| 2000 | 0.001800 | 0.0015180 | 0.001708 | 0.001652 |
| 2500 | 0.001806 | 0.0015230 | 0.001709 | 0.001656 |

## CONCLUSION

In this paper, we have studied the network selection problem in 5G heterogeneous networks. We have proposed a network selection mechanism and formulated an optimization problem for network selection to minimize the interference to primary networks and cost paid by SUs. We then solved the optimization problem with the PSO and modified GA in order to find near-optimal solution.

## REFERENCE

**[1]** Najam ul Hasan,Waleed Ejaz,Naveed Ejaz,Hyung Seok Kim,Alagan Anpalagan, and Minho Jo,"Network Selection And Channel Allocation for Spectrum Sharing in 5G HeterogeneousNetworks,"IEEE Communication Magazine.

[2] C. V. N. Index, "Global mobile data traffic forecast update 2014–2019. white paper c11-520862,"Availableonhttp://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networkingindexvni/white paper c11-520862. html.

[3] S. Chen and J. Zhao, "The requirements, challenges, and technologiesfor 5G of terrestrial mobile telecommunication," IEEE CommunicationsMagazine, vol. 52, no. 5, pp. 36–43, May 2014.

[4] M. Iwamura, "NGMN View on 5G Architecture," in Proc. of IEEEVehicular Technology Conference (VTC Spring), Glasgow, Scotland,May 2015, pp. 1–5.

[5] H. Droste, G. Zimmermann, M. Stamatelatos, N. Lindqvist, O. Bulakci,
J. Eichinger, V. Venkatasubramanian, U. Dotsch, and H. Tullberg,
"The METIS 5G Architecture: A Summary of METIS Work on 5G Architectures," in Proc. of IEEE Vehicular Technology Conference (VTCSpring), Glasgow, Scotland, May 2015, pp. 1–5.

[6] P. Agyapong, M. Iwamura, D. Staehle, W. Kiess, and A. Benjebbour,"Design considerations for a 5G network architecture," IEEE Communications Magazine, vol. 52, no. 11, pp. 65–75, Nov. 2014.

[7] A. M. Akhtar, X. Wang, and L. Hanzo, "Synergistic Spectrum Sharing in 5G HetNets: A Harmonized SDN-Enabled Approach," IEEE Communications Magazine, vol. 54, no. 1, pp. 40–47, Jan. 2016.