ENERGY EFFICIENT CO-OPERATIVE SPECTRUM SENSING USING GENETIC ALGORITHM AND PARTICAL SWARM OPTIMIZATION: A REVIEW

[1]Nisha Morasada, [2]Ketki Pathak, [3]K.G. Bhuva
[1]Electronics & Communication department, Dr. S. & S. S. Ghandhy Government College, Surat, India ,
[2]Electronics & Communication department, Sarvajanik College of Engineering and Technology Surat, India,
[3]Electronics & Communication department, Dr. S. & S. S. Ghandhy Government College, Surat, India
[1]nishamonasara@gmail.com,[2] ketki.joshi@scet.ac.in, [3]kgbhuva_me_ec@yahoo.co.in

Abstract*—Wireless technologies have grown rapidly and needs more spectrum resources to support numerous emerging wireless services. Spectrum Sensing in cognitive radio (CR) protects the authorised user from the effect of pathetic interference that is caused by either cognitive users or other environmental parameters. In spectrum sensing there are two different challenges; first the CR has to detect channel under lower SNRs which increases the sensing time, and second is thatamong all CR nodes some nodes have experience the effect of deep fading and shadowing. So to solve this challenges Cooperative spectrum sensing is supposed to be used. But for CSS CRs needs extra energy to send the sensing result to the fusion centre and receive the final decision from the fusion centre. So this procedure increases the energy consumption. Therefore, CSS process may consume considerable energy from the battery of the CR node. Second-hand users (SU) of a cognitive radio station (CRN) are from healthy devices supplied by batteries, the sources of energy are relatively precious and it is desired that minimum power should be consumed from battery so it should be clear that one should use energy in a effective manner. In this paper different energy efficient algorithms are discussed like genetic algorithm and particle swarm optimization. Using this optimization techniques the overall energy consumption is reduced, and energy efficient cooperative spectrum sensing is done to maximize throughput.

Index Terms—*Cognitive Radio Network, Co-operative spectrum sensing, Genetic Algorithm, Particle Swarm Optimization*

I.INTRODUCTION

Radio spectrum may be anexpensive source and it happens many times that, most of allotted band isn't properly used by licensed users in any respect the time. Currentlya days the fast growth of wireless technologies will increase the need for radio-frequency spectrumband. Federal Communications Commission (FCC) used the steady(static)Spectrum Allocation (SSA) theme to portion spectrum bands to users. Butlicensed users don't occupy radio-frequency spectrum fully and as a result spectrum is underutilized. As an answer to the spectrum unskillfulness drawback, Cognitive radio (CR) is associate degree exciting and adaptive new rising technology, that has projected by joseph mittola to reinforce the employment of restricted resources.CRs has two main characteristics; first is cognitive capability and second is Re-Configurability. Cognitive capability is define as the ability of radio to detect the data from radio(wireless) environment and the definition of Re-Configurability is that, it is the ability to swap its task in according to the sensed environmental parameters.

To achieve higher spectrum utilization authorized users (PUs) have existence with the unauthorized users (SUs) within the same waveband in CR network. Additionallywillsay that SUs can use the authorized spectrum some times when it is free but should not disturb PUs. By applying CR Radio network utilization scheme, the band sources may be assured to reinforce the spectrum(band) potency so considerably will increase the quantity of users that will use wireless aminities, that might solve the matter of spectrum inadequacy.

Though, detection performance could also be plagued by shadowing impact, multipath impact and also the hidden terminal drawback and because of this drawback SU might not discover the action of the element inside the small duration of sensing amount. To mitigate that problems co-operative spectrum sensing is employed.

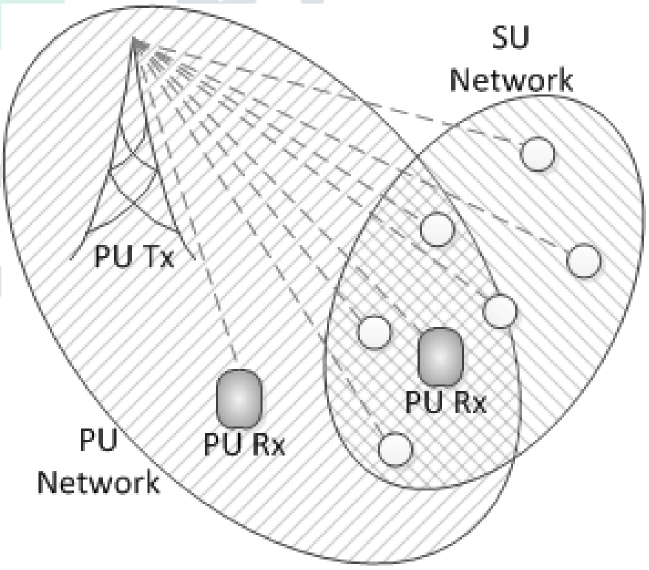

Figure 1. Primary and Secondary user coexistence in the CRN [2]

This paper is organized in the manner as below. First the fundamentals of co-operative spectrum sensing are discussed in section II in which the algorithms like genetic algorithms and Particle swarm optimization are also simplified. In section II there is also a performance parameters were mentioned. In section III there is a brief literature survey is there. Section IV contains applications of CRN and co-operative spectrum sensing. In section V there is a conclusion that is gain at the last of literature survey.

NOMENCLATURE

CRN	Cognitive Radio Network
PU	Primary User
CSS	Co-operative Spectrum Sensing
SUs	Secondary Users
FCC	Federal Communications Commission
SSA	Static Spectrum Allocation
GA	Genetic Algorithm
PSO	Particle Swarm Optimization
MOCSO	Multi Objective Cat Swarm Optimization
IWO	Invasive Weed Optimization
MOGA	Multi Objective Genetic Algorithm
NSGA	Non-dominated Sorting Genetic Algorithm
NSIWO	Non-dominated Sorting Invasive Weed Optimization
MOPSO	Multi Objective Particle Swarm Optimization
DE	Differential Evolution
HDF	Hard Decision Fusion
SDF	Soft Decision Fusion
MDC	Modified Deflection Coefficient
C-PSO	Cluster based Particle Swarm Optimization
PCs	Multiple Primary Channels

II.CO-OPERATIVE SPECTRUM SENCING

In a cognitive radio network by using co-operative spectrum sensing each and every nodes sense the spectrum and report their own decisions to fusion centre so by using the global probability of detection the global decision is acquired.

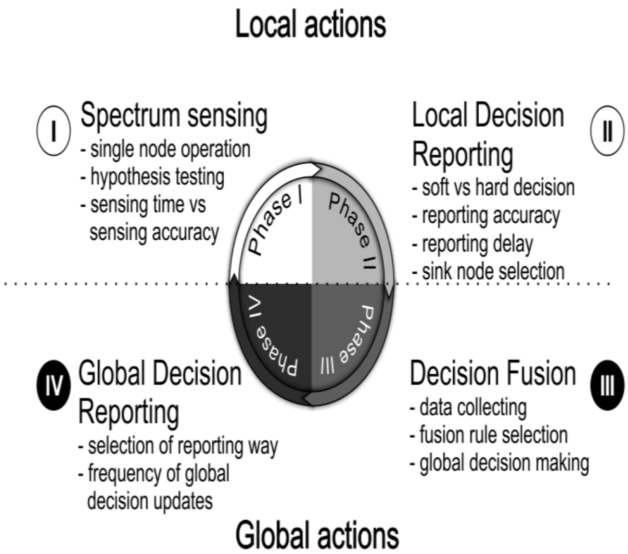

Figure 2. Cooperative spectrum sensing procedure [2]

The aim of spectrum sensing for the secondary users – SU isto make the decision that PUs use the channel or not. If a SU identify that r(x) signal is present then, the decision of spectrum sensing D(x) can be consider under a twice hypothesisstatistic test: [2]

D(x) ={H0 if r(x) = n(x)}; and
D(x) = {H1 if r(x) = s(x) + n(x)};

Here H0 designatethat the received signal is only noise signal n(x), i.e., the band of that frequency is empty, and H1 indicates that the r(x) is the sum of authorised user signal s(x) and noise signali.e., that frequency band is not empty some PU use that channel[2].

In accordance with the co-operative spectrum sensing, there are so many different methods use for the optimization of sensing energy and throughput. From that methods we have analysed two methods in this paper, those are genetic algorithm (GA) and particle swarm optimization (PSO).

A. *Genetic Algorithm*

GA is an method that change parameters according to the situation to solve the search problem. It is based on parallel search of the chromosome group, selecting operations with guessing, switching operations, and mutation operations. So, GA has the following characteristics.[3]

GA begins its search from the collection of problem solutions, instead of the singlular solution. At that point there is a wise difference between GA and conventional optimization algorithms. The conventional (earliest) optimization algorithms get local optimal solutions easily because they obtain the optimal solution from a only one initial value iteration. GA begins its search from the set of problem solutions. So, it covers a wide area and it is good for global choice.[3]

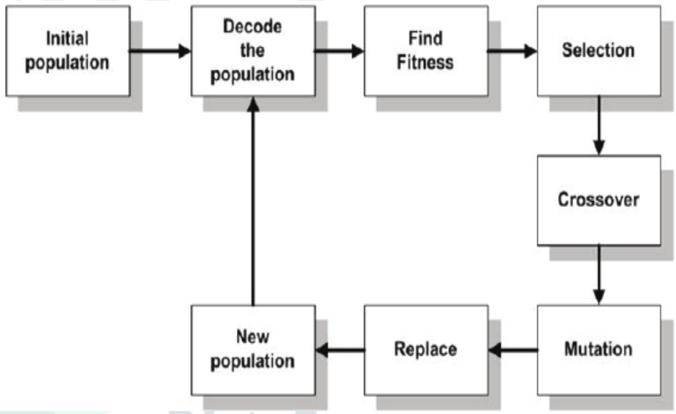

Figure 3. Genetic Algorithm Block Diagram [21]

GA does not need additional information, It uses the fitness function value to determine individuals and takeaway genetic operation. The fitness function is not limited to continuous differentiable functions, and its definition domain can be set randomly. This feature greatly elaborate the application range of GA.GA adopts the changing rules of probability rather than deterministic rules to guide its search direction.[3]

To organize the search when information of the evolution process is used by the GA, the individual with large fitness value has a more probability of survival and can get a more adaptive genetic structure. [3]

B. *Particle swarm optimization*

Particle Swarm optimisation (PSO) is associate rule to unravel optimisation issues. In a PSO, there are many particles that have some random starting position and speed within the search area.Every particle is thought as a personal and collection of more number of particles is thought as swarm. The target is to search out the most effective resolution for the stated disadvantage.[4]

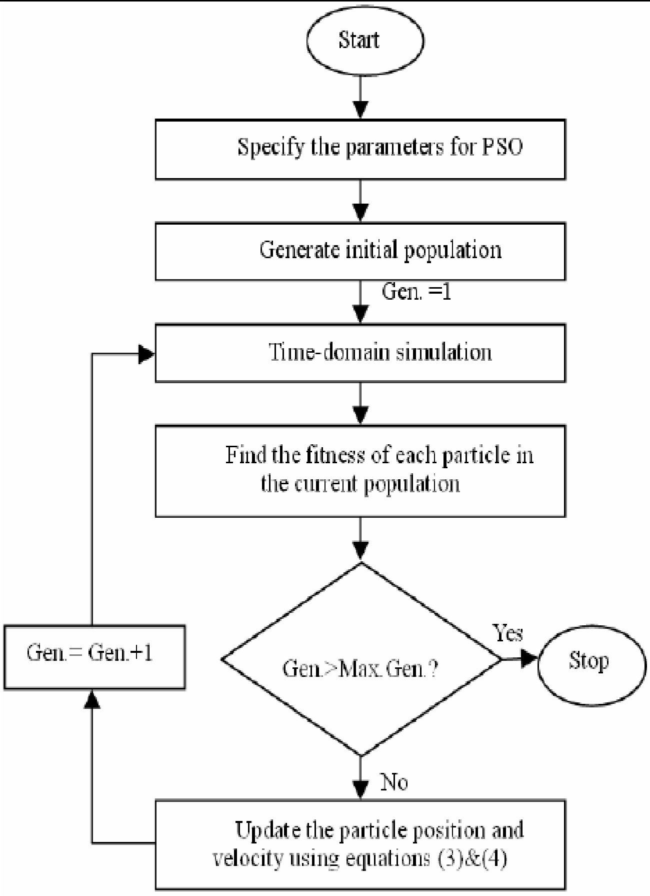

Figure [4]. Basic bock diagram of PSO algorithm [22]

A point within the search space can offer the optimum answer. Each particle have some speed and according to that it will move in some directions.With each and every iteration the position and speed of particles is updated. At a time, each particle has its own personal best position and a worldwide best position of the collection of all particles (swarm). Now for the next stage all particles moves to the world (global) best position of the swarm. If the position of any particle is nearer to the most probable effective answer then Global best position of the population are updated. [4]

Now, the particle that has the position which is nearer to the exact answer will be a leading one in a swarm and position of that leading particle is become a global best position. After that every particles can start moving in the direction of that updated particle's direction. This procedure is repeat until all the particles converges at one purpose of the search space. The point at which all the particles converges is called as the optimal solution of the given objective function. [4]

C. Performance Parameters

The performance parameters of various papers are as follows:

i. **Detection Probability**: It is the probability that recognise a busy channel as busy and idle channel as idle.

$$PD = 1-(1-PDS)^{Ns}$$

Where Ns is the number of sensing nodes and PDS.is the singular probability of detection.

ii. **False alarm Probability**: It is the probability that the FC recognise an idle channel as busy (P(H1/H0)) and busy channel as idle.

$$PF = 1-(1-PFS)^{Ns}$$

Where PFS is the singular probability of false alarm.

iii. **Sensing Energy Consumption:**It is The energy utilize in the sensingby the NS CR nodes is given as follow.

$$\mathrm{Es} = \sum_{i=0}^{Ns} Ti\,s \times \rho s$$

And T^i_S is the sensing time of i[th]number of CR node and ρs is the energy utilized in sensing per unit time.

iv. **Reporting Energy Consumption:** It is given as follows.

$$Er = \sum_{i=1}^{Ns} \mathrm{D}^2 i - FC \times \tau \times \rho r$$

Where D^2i-FC is the distance square among the FC and i[th]number of CR node and ρr is the energy utilized in reporting per unit time.

v. **Achievable Throughput**: It is theaverage of correctly transmitted bits in single frame (T).

$$Th = P0 \times (1-PF) \times Dt \times Tt$$

Where Dt is on the channel data transmission rate in bits/second and Tt is Transmission Rate.

vi. **Energy Efficiency Maximization**: Energy efficiency is defined as the ratio of throughput to energy consumption. Therefore, maximizing it achieves the balance point between energy consumption and average throughput.

$$\max \mu(N, Ts) = \max(\mathrm{N}, \mathrm{Ts}) \frac{\mathrm{P0} * (1-\mathrm{PF}) * \mathrm{Dt} * \mathrm{Tt}}{\mathrm{Es(N)} + \mathrm{Er(N)} + \mathrm{Pfree} * \mathrm{Et(N)}}$$

III. LITERATURE SURVEY

This section articulates the details about the background literature study we have done on the technologies, algorithms and papers proposed on cooperative spectrum sensing using GA and PSO. Provided below are the reference papers we have leveraged upon to develop a base of this review paper, and creating the foundation of our research:

Fuzzy decision making and multi-objective evolutionary algorithmsIn 2013 are used by**Pyari Mohan Pradhan and Ganapati Panda[5]**for the approach of cooperative spectrum sensing in CRN. CSS make use of spatial diversity in between CRs to increase sensing accuracy. The selection of the weight assigned to each CR and the universal decision threshold can be made as a constrained multi-objective optimization problem where PF and PD are the two incompatible motives. In this research articleevolutionaryschemes are used to solve its optimization problem in a multi-objective framework. By literature review it is clear that their approach that is on the base on the idea of cat swarm optimization outperforms another schemes as a measure of non-dominating solutions &effective implementation. For the bunch of compromise solutions fuzzy logic dependent scheme is used.To assess the stability which is offered by the heuristic evolutionary algorithmsvarious examinations are takes out for this. The evaluation of different performance matrices like Fuzzy decision making Computation time (T), Moment of inertia metric (I) and Set coverage metric (C) is done. CSS performance metrics are optimized using MOCSO scheme. MOCSO scheme is used to determine the reliable solutions of CSS framework. In MOCSO scheme there is a fitness sharing mechanism is there, which spread the non-dominated solutions through Pareto front.

A Cooperative Spectrum Sensing theme victimization Multi-objective Hybrid IWO/PSO formula in psychological feature Radio Networks was proposed in 2014 by**Deepa Das and Susmita Das[6]**. The writers of this article invented a new approach that is MO hybrid IWO/PSO based soft call fusion (SDF) scheme for improve the world call threshold and weight constant vector appointed to every psychological feature users (CUs) so as to maximize the detection chance, and decrease the warning chance and overall chance of error at the identical time. For Detection accuracy and nondominated solutions the authors propose NSGA-II, MOPSO and NSIWO. S-matric (spacing), C-matric (coverage of 2 sets) and that i –metric (moment of inertia) are the performance parameters for this work.By using Detection performance will improve with this projected technique with some more computation period than MOPSO and NSGA-II.The trade-off should be thought of between the sensing time and therefore the detection accuracy so as to confirm secure use of band. Also noise uncertainty are often enclosed within the system therefore on gives better the detection potency at lower SNRs no matter condition.

Introduction of an optimization of Probability of False alarm and Probability of Detection Cognitive Radio Networks using GA was done by**Subhasree Bhattacharjee, Priyanka Das, Swarup Mandal, and Bhaskar Sardar[7] in 2015.**In this paper to decrease error probability (BER) of a specified SU in a centralized CRN using Genetic algorithm (GA) they optimize PD and PF in CRN.The motive is to decrease probability of error (BER) and finding optimum values of probability of occupancy detection or probability of detection and probability of false alarm. Centralized cooperative sensing framework is considered in this paper. Here the main motive of authors was to decrease probability of error (P_{jerror}) of a specified SU j. Probability of error is the sum of two terms. First term is Pf multiplied with the probability of PU being absent, Second term is probability of misdetection multiplied with probability of PU being present. So the objective of this paper is to find optimized values of $P_{jdetand}$ $P_{jfalarm}$ of a particular SU j so that P_{jerror} of that unauthorized user can be reduced.

GAs are adaptiveiterative search algorithms. GA has been quite self-made optimisation technique which will solve completely various unnatural or at liberty optimisation issues. Differential evolution (DE) is another organic process algorithmic rule that has been used for developing most effective system that has a multiple motives. Diamond State is incredibly easy however noticeably effective feature, developed by worth and Storn. During this article authors examine the results of GA and collate them with Diamond State to seek out that algorithmic rule is additional appropriate in resolution the actual optimisation drawback. The result's collated with Differential Evolution algorithmic rule and it's evident from the comparison that Diamond State finds higher answer and takes abundant lesser range of evaluations to seek out optimum answer. additionally to it for a hard and fast population size Diamond State takes lesser time for one iteration than GA.

In 2016 **Abdulkadir Celik, Ahmed E. Kamal**[8] proposed a new work on "Multi-Objective Clustering Optimization for Multi-Channel Cooperative Spectrum Sensing in Heterogeneous Green CRNs". Energy economical (EE) CSS strategy for large scale heterogeneous CRNs that include multiple PCs and enormous variety of SUs with heterogeneous sensing and reportage medium standards. The difficulty was approached by macro and (micro) small perspectives;

Macro view combine SUs into clusters by the aim of : 1) Total energy consumption reduction, 2) Total throughput increment, and 3) Inter-cluster energy and throughput fairness.

The small(micro) perspective works as a sub-strategy on cluster development determined by the macro scheme. For the small views, authors 1st develop a system to pick out the cluster head (CH) that yields: 1) the most effective CH which supplies the least total multi-hop error rate, and 2) the best routing ways from secondary user to clutter head. Exploiting Poisson-Binomial distribution, a unique and generalized K-out-of- N selection rule is developed for heterogeneous CRNs to permit SUs to own totally different native detection performances. Then, a convex optimization framework is developed to attenuate the intra-cluster energy value by together getting the best sensing periods and thresholds of feature detectors for the projected selection rule. Rather than a typical fastened sample size check, authors developed a weighted sample size check for amount soft call fusion to get a lot of applied science regime below heterogeneousness. thought of the sensing and reportage heterogeneousness below each HDF(Hard call fusion) and SDF(soft call fusion) primarily dependent CSS encompasses a vital effect on the intra-cluster energy utilization and possible turnout. Projected novel HDF theme is tends impose to SUs with comparatively higher SNRs to own an ideal native detection performance whereas the lower SNR SUs' native detection is discharged. Subject to world detection and warning likelihood constraints, this system is more economical than the normal systems.

Authors **Ibrahim Salahl, Waleed Saad, Mona Shokair, and Mohamed Elkordy[9]** proposed work on Minimizing Energy of Cluster –Based Cooperative Spectrum Sensing in CRN using Multi Objective Genetic Algorithmin 2016. In this paper, authors planned approach supported cluster to attenuate the entire power utilized by CRN so as to do spectrum sensing send information to cluster head, and send information to the fusion center. That is often carried by victimisation multiple motive genetic rule. This planned rule are able to do higher energy gain that is a smaller amount than typical cluster based mostly CSS theme. Moreover, it will increase performance of CRNs. this could be want to decrease network wide energy utilization as digital communication and spectrum sensing energy prices. Moreover, it will increase life of the network.

CSS supported the efficient PSO in CR was introduced in 2016 by **Yu Deng and Xi Yanga[10]**. Within the projected methodology, the edited PSO is used to get the optimum weight vector to maximise the chance of detection by dynamical the inertia weight changes according to parameters in every iteration. The projected methodology performs higher in convergence than the strategy supported the normal PSO. Additionally it will convalesce detection chance than the corrected (Modified) deflection constant (MDC) methodology. The projected methodology is economical and stable. The convergence speed of it is quicker than the normal PSO. At the identical time, the projected work perform better than the MDC-based optimisation methodology. The algorithms utilized in this paper will acquire higher chance of detection than the MDC based mostly methodology once the identical target chance of warning is given.

In 2017 **Shaojie Zhang, Abdelhakim Senhaji Hafid, Haitao Zhao, Shan Wang[11]** proposed approach on Impact of Heterogeneous Fading Channels in Power Limited Cognitive Radio Networks. The impact of diverse weakening channels on the presentation of power restricted CRNs is analyzed within the presence of the trade-off between the interference likelihood to element and SUs' aggregative outturn in that article. The trade-off aiming at increasing SUs' aggregative outturn underneath 2 constraints: (i) interference likelihood to element and (ii) SUs' average power consumption to resolve the optimisation drawback, authors style a completely unique cluster based mostly particle swarm optimisation (C-PSO) algorithmic program. By iteration wise change the particles in a very cluster supported the differentiation of their fitness, the cluster converges to the best answer chop-chop. Practicablenessof the C-PSO algorithmic program was validate by the results and also the performance of our proposal is better compared against connected contributions that contemplate the unvaried weakening channel. They conjointly show however the best answer changes with path losses and Primary User's traffic distribution. The sensing period, frame period, detection threshold and transmit power are put together optimized through C-PSO algorithmic program for a better SUs' outturn performance underneath interference likelihood and power utilization limitations.

A novel work on "Multi-Objective best Resource Allocation victimization Particle Swarm Optimisation in Cognitive Radio" was done in 2018 by **Hamza Khan Sang-Jo Yoo[12]**. During this article, every SU has its own knowledge traffic demand appropriate for his or her currentlyused works and energy saving dictate. To capture the various sensing necessities for channels thanks to the channel specific primary activity, authors developed anaggressive raincoat frame arrangement technique, during which sensing period and length of frame are reconfigurable parameters. Using PSO rule, they choose AN optimum channel and confirm raincoat resource allocation for every SU supported its sensing info and repair demands, during which they increase the secondary capability and supply fairness among SUs. Authors outline 2 fitness functions.

Utilization operate is to maximize secondary add capability and supply honest data service to member nodes.

The energy saving utilization operate is to capture the energy saving requirements of member nodes.

And the methodology is appropriate in speed of convergence, increasing the given motive criteria and gives equity among the different nodes.

IV.APPLICATIONS

Under the examination of spatially situated CR user, the main application of CS is to boost the sensing efficiency by using spatial diversity. Decision by only one node is not more efficient but using the co-operation scheme all the nodes send their local (own) decision to FC and that that FC decide the availability of channel so in this way there is more precise decision would be derived [14]. By using spatial diversity increment in a performance is called cooperative gain. The cooperative gain is conjointly viewed from the perspective of sensing infrastructure. As a result of multipath attenuation and shadowing, the S/N (SNR) of the received authorized signal is very tiny and also the detection of that becomes a tough task.

Multipath and shadowing impact degrade the performance of system which is overcome by CSS. In CSS process sensitivity of receiver is set nearer to the value of ideal nominal path loss. But there is a condition to not to increase the manufacturing price of CR device.[15].

At any instant of time by using co-operation of node if sensing time is decrease then the time for data transmission in that slot will increase. Which means that it will increase the turnout. That increment in turn out is also an added factor of co-operative gain. So by using the proper CSS mechanism one should get a proper throughput in a reliable range of co-operative gain. [16].

The summary table of literature review is given below.

Paper	Publicati-on & Year	Summary	Research Gap
Cooperative spectrum sensing in cognitive radio network using multi-objective evolutionary algorithms and fuzzy decision making	journal of ad hoc network, voume 11,issue 3 & November 2012	CSS performance metrics are optimized using MOCSO scheme. MOCSO scheme is used to determine the reliable solutions of CSS framework. In MOCSO scheme there is a fitness sharing mechanism is there, which spread thenon-dominated solutions through Pareto front.	To minimize the entire processing time MOCSO methodology is used. One needs to finding out the controversy between quality of solution and processing time in depth.
A Cooperative Spectrum Sensing Scheme UsingMultiobjective Hybrid IWO/PSO Algorithm inCognitive Radio Networks	2014 International Conference on Issues and Challengs in Intelligent Computing Techniques (ICICT) & Feb 2014	Authors developed a linear framework that is based on the energy detection. To reduce the PFS, probability of error and to increase the PDS at the same time THE MO hybrid IWO/PSO methodology was invented with the reduction in weight and global threshold.	To use the band in secure way there must be a controversy among the sensing time and PDS. Also there is a way to add noise uncertainty with lower SNRs to improve detection accuracy.
'Optimization of Probability of False alarm and Probability of Detection in Cognitive Radio Networks Using GA'	IEEE 2nd international Conference on Recent Trends in Information Systems (ReTIS) & July 2015	It is summarized that the factor Pjerror is mostly deend on the parameters Pjdet and Pjfalarm. At the time of 300 generation east fitness value is 0.224110 and also the value of Pjfalarm and Pjdet is 5.568114 and 7.875056 respectively and at the last that conclusion is made that DE takes less generations and give better solution.	One should extend the mechanism for calculatingprobability of error (BER) in distributed radio environment.
Multi-Objective Clustering Optimization for Multi Channel Cooperativ e Spectrum Sensing in Heterogeneous Green CRNs	IEEE Transactions on Cognitive Communications and Networking (Volume: 2 , Issue: 2 & June 2016	The BEP wall principle was compensated by the multihop reporting and channel selecting procedure. Minimum routing paths from CH to SUs and mechanism to find better Chis finding out using multipath diversity. The parameters seems better in the way of cost, energy and robustness to reporting channel which is not perfect.	To achieve better throughput and energy efficiency the macro perspective and micro perspective more efficient algorithm should be developed.
Minimizing Energy of Cluster -Based Cooperative Spectrum Sensing in CRN using Multi Objective Genetic Algorithm	12th International Computer Engineering Conference (ICENCO) & February 2017	The Methodology is used to reduce energy utilization. Here the outcome is better than the conventional clustering mechanism. The work is useful in reducing the cost and increasing the life time of network	Tradeoff between the performance and energy efficiency.
'Cooperative spectrum sensing based on the improved particle swarm optimization in cognitive radio'	Wireless communication and sensor Networks & 2016	The convergence speed of PSO based method is more than the conventional PSO also it is stable and efficient. The method that is used here has high PDF then the MDC based mechanism at the time of equal target PFS.	If the target probability of false alarm is different at that time probability of detection is also very and it may be higher or lower than the MDC based method.
Impact of Heterogeneous Fading Channels in Power Limited Cognitive Radio Networks	IEEE Transactions on Cognitive Communications and Networking (Volume: 4 , Issue: 1) & March 2018	There is a controversy in between interference probability to authorized user and unauthorized user throughput. Under the use of limited power utilization and interference probability the parameters like sensing and frame interval, detection cutoff and transmissionpower are jointly optimized by C-PSO method.	There is a assumption that every unauthorized users Suffer from the same channel fading, but for some SUs this assumption may not be true. At that time throughput may be very.
'Multi-Objective Optimal Resource Allocation Using Particle Swarm Optimization in Cognitive Radio'	", IEEE Seventh International Conference on Communications and Electronics (ICCE) & July 2018	In the article there is a bio-inspired methodology was introduced by variable frame architecture and resource allocation scheme. And the methodology is appropriate inspeed of convergence, increasing the given motive criteria and gives equity among the different nodes.	Channel sensing time was obtained by using the primary activity and required interference protectionprobabilitySo by changing that parameters one should achieve required energy efficiency.

V.CONCLUSION

Cooperative spectrum sensing using genetic algorithm and particle swarm optimization is done in previous Literature. some methods for the cluttering based CRNs were proposed. By using this two GA and PSO based optimization strategies the total energy consumption by Cognitive radio is minimize.in this paper there are so many different methods where analysed and according to that it is concluded that multiobjective genetic algorithm is best for cluttering based CRs. Also the PSO is used to improve Secondary user's throughput under the effect of interference probability and power utilization imitations.

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