ISSN 2278-3091
Volume 9, No.1, January – February 2020
International Journal of Advanced Trends in Computer Science and Engineering
Available Online at http://www.warse.org/IJATCSE/static/pdf/file/ijatcse54912020.pdf
https://doi.org/10.30534/ijatcse/2020/54912020

Probabilistic Approach for Channel Selection in Centralized Cognitive Scheme Utilizing Invasive Weed Optimization

D. Sumathi[1*], S. S. Manivannan[2]
School of Information Technology and Engineering (SITE),
Vellore Institute of Technology, Vellore, India
[1*]dsumathi@vit.ac.in, [2]manivannan.ss@vit.ac.in

ABSTRACT

Devices of cognitive Radio (CR) help Secondary Users (SU) to locate a vacant channel licensed to Primary Users (PU). SU vacates the channel by doing a handoff on condition when PU enters that channel. Now SU seeks a different channel to proceed further. This paper narrates an algorithm of an evolutionary type called Invasive Weed Optimization (IWO) that solves the issue of Spectrum Handoff (SHO). The fixed and Probabilistic method of hybrid spectrum handoff utilizes the algorithm of IWO. The prime limitation of SUs' prolonging the time in data delivery gets minimal by optimizing the period in the network of CR. The centralized Cognitive Device (CCD) is minimizing delay in handoff, monitoring the balancing of the load as well as improving efficiency. The proposed method is verified and validated with the existing Genetic algorithm (GA) and Particle Swarm Optimization (PSO) methods. Apart from that the pre-emptive resume priority MG/1 model for queuing too is employed. This leads the IWO method's accuracy of channel selection to an improvement of 97.6%. There is a greater reduction in handoff delay. This excels in the schemes of traditional type in practice now.

Key words - Cognitive radio, invasive weed optimization, spectrum handoff, non-identical channels, evolutionary algorithm, probabilistic approach and queuing theory.

1. INTRODUCTION

Many applications now in wireless field needs networks with heterogeneity as well as higher capacity. The technique of Cognitive Radio (CR) now ushered in is capable of hunting the available spectrum [1]. The CR is sensing power to do transmitting, modulation, frequency, selecting parameters to obtain improved Quality of Service (QoS) as well as bandwidth. The CR is sensing on a real-time basis as it adapts the forming of mesh network as well as it supports schemes that get self-organized. The CR's temporal learning of' characteristics of channels during a period is helping to select a channel in an improved way. While a handoff is done by a Secondary User (SU) to a PU, SU maintains a link by employing the CR with no interference with other clients. In addition a change in frequency is expected [2-3]. The CR scheme level handoff of the spectrum to transmit as well as selecting bands of frequency expected are done by the algorithm for such control. It does channel selecting as well as changing the frequency of band in a better way. The search is initiated by routing. Here, a channel is preferred that has a longer period of vacancy. This minimizes the break-otherwise-drop handoff. Interfering with existing systems other than this is reduced too.

This paper reviews the functions of CR on frequency changing, handoff of the spectrum, functionalities of managing channel as well as the impact count of handoffs of the spectrum. In addition accuracy, the delivery time of data, delay due to handoff as well as the effect on throughput related to SUs while it transmits. It includes the Dynamic Spectrum Allocation (DSA) aspects of the cognitive scheme. Apart from this the proposal is made with the algorithm of IWO as well as handoff of the spectrum of the hybrid type which are fresh algorithm schemes to select the channel that are optimized. The proposed research provides a scheme utilizing probability principles for combining a method to select frequency as well as locating a free channel that is mostly unoccupied.

Fixed and probabilistic optimizing sequence schemes (expressed in the form of a matrix) for minimizing the lengthy delivery time for data. A comparison of those schemes must be done with IEEE 802.22 standards for Wireless Regional Area Network (WRAN). Proposed another metaheuristic method namely, Invasive Weed Optimization to achieve more efficient optimizing which maps from a varied electrical area improving it in the wireless field. The remaining portion of the paper is structure as follows. The system model is described on Section 2. Section 3 contains SUs' handoff of the spectrum with the algorithm of IWO in the proposal. Section 4 has implementing of SUs' handoff of spectrum utilizing IWO. Section 5 explained about the simulated results and discussions.

2. SYSTEM MODEL FOR CENTRALIZED PRE-EMPTIVE RESUME PRIORITY (PRP) M/G/1 QUEUEING MODEL

The specific assumptions are included in present modelling. To start with, a method is assumed that contains slotted time. At the initial stage of each slot, SU senses whether the channel is free or it is occupied by PU. An empty channel is detected by SU to start transmitting. A false channel may be detected. This scheme neglects that [4], [6], [9].

One channel can be modelled by the queuing model of pre-emptive resume priority (PRP) M/G/1. The former researches show concern regarding the schemes to select proactive target channel in the [4-11], but what is proposed now is the extension of those concepts utilizing a better algorithm for optimizing to serve a generalized channels which are not identical. The service rates in this situation differ among different channels. The service times as well as inter-arrival $\mu_{se}^{(kt)}$ as well as $\lambda_{se}^{(kt)}$ respectively, are under the assumption that they are independent; they change in an exponential way with SU's rates and $\lambda_{IS}^{(kt)}$ as well as $\mu_{IS}^{(kt)}$ for SU being interrupted at channel $1\le k_t \le M_t$; here M_t is the number of channels in totally counted channels. Also, it is assumed that those channels are being independent as well as non-identical with each other as they follow differing service rates. The top priority is for PUs is the basic assumption. When a PU interrupts a SU and starts transmission, SU finds if the service time of its own is more than the service time of PU. In case it is so the SU that faced interruption is waiting on the same channel. Subsequently, the PRP principle is executed with the following two queuing assumptions: interrupted SU has a high priority in the queue; other SUs have low priority and wait. The transmission is better now as well as no data loss.

The proposed work in this paper utilizes the network queuing model of the (PRP) M/G/1 as shown in Fig.1. The M/G/1 (1 stands for single queue analysis) shows a basic mathematical modelling [12] following users arriving in the Poisson pattern process; the processing period, that service rates of users are independent, identically distributed and it is in exponential fashion too. The interrupted SU can wait at the present channel for PU to finish its transmission. The alternative is SU is taken to the high priority queue. That SU receives the chance first to transmit; others wait in that channel with low priority. The extremity is there; perform spectrum handoff of and go to another channel. This distribution enables to model client's inter-arrival time or service rates. The Poisson distribution enables to determine the particular number of arrival probability at a particular time. These stages are carried out as well as the arrival order process is followed (FCFS). The necessary and definite condition is:

$$\rho = \frac{\lambda}{\mu} < 1 \tag{1}$$

Else queue length will explode. By assuming mentioned facts the state of the spectrum system can be described at a point of time which is arbitrary by doing simplification of the tasks' count in the system. If rates of inter arrival as well as processing times are exponential, then the time distribution until the next one is arriving or completion of service is not affected by the elapsed time from the last arrived and last service completion. This is due to the *memory less property* in an exponential distribution form. In the FCFS order process means the past has no information waiting for users in the queue. The network queuing model (PRP) M/G/1 is chosen as the queuing model during the absence of buffer or when there is no population size limit. In addition to implementing the mean arrival rate and mean service rate alone being available will suit this area.

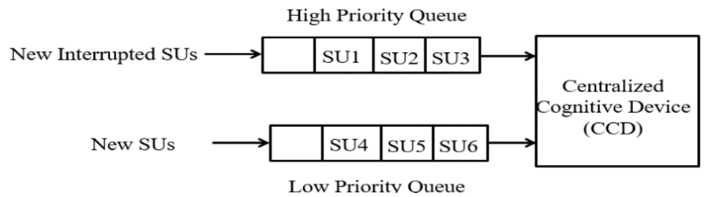

Figure 1: Centralized Pre-emptive resume priority (PRP) M/G/1 queuing model

To select a target channel, a Centralized Cognitive Device Network Manager (CCDNM) is utilized. For SUs it is improving efficiency, accuracy as well as minimizing battery energy. The handshake signals count too is minimal. Either based on a fixed sequence or probabilistic sequence, each SU is linked with each other. Related to target channel rates as well as the one that exists (as non-identical rates are assumed) is modifying the remaining service times. The two mentioned schemes are generated and enumeration is done [4-5]; they are of fixed sequence transition matrix form R_{fixed}; next a sequence of stochastic sort R_{prob}. Optimizing these matrices yield minimal extended data delivery period.

$$R_{fixed} = \begin{pmatrix} s_{1,1} & s_{1,2} & \cdots & s_{1,Mt} \\ s_{2,1} & s_{2,2} & \cdots & s_{2,Mt} \\ s_{n_{max},1} & s_{n_{max},2} & \cdots & s_{n_{max},Mt} \end{pmatrix} \tag{2}$$

$$R_{prob} = \begin{pmatrix} r_1^{(1)} & r_1^{(2)} \dots & r_1^{(Mt)} \\ r_2^{(1)} & r_2^{(2)} \dots & r_2^{(Mt)} \\ r_{Mt}^{(1)} & r_{Mt}^{(2)} \cdots & r_{Mt}^{(Mt)} \end{pmatrix} \tag{3}$$

Here in $s_{i,\eta t}$ denotes the target channel of SU, whereas the default channel is η_t and it is after i^{th} interrupted time, the overall number of permitted interruption before connectivity was dropped is shown as η_{max}. The channel selection probability is k_t when the default channel of SU η_t is $r_{\eta t}^{(kt)}$, $1 \le k_t$; $\eta_t \le M_t$, and $M_t$is the entire channel count of s.

3. PROPOSED IWO ALGORITHM IN THE SPECTRUM HANDOFF FOR SUs

Step 1: SUs are based on the number of variables chosen around the process' probability of search boundary. Random initialization of seeds is present or seeds are randomly dispersed in solution space, so that the seeds' mapping is carried out based on the number of SUs.

Step 2: On the fitness function basis, the fitness of SU (later to initializing) is evaluated (or) to optimize objective function is selected. The fitness attachment point is separately calculated for doing handoff. For joint objective function optimization, the following equation is used.

To form a combined cost function for achieving the load balance as well as joint optimization of overall extended data delivery time in the coverage area of 1st/ 2nd Network: [2].

$$G(X, \alpha 1, \alpha 2) = \alpha 1 \{E[T_{prob}(\text{or})T_{fixed}]\} - \alpha 2 \sum_{1\le i\le P+Q} w(i) \left(\frac{\ell \text{i} + \gamma_i(X)}{z_i}\right)^2 \quad (4)$$

Subject to $\ell_i + \gamma_i(X) \le z_i$, *for* $1 \le i \le P+Q$

Case 1: α1≡1, α2≡0: When SU wishes to minimize total extended data delivery time then alone a handoff decision occurs: EDD-L.

Case 2: α1≡0, α2≡1: Considering the new attachment point load traffic and balancing in all dissimilar attachment points, a handoff decision is made: OPTF.

Case 3: α1≡1, α2≡1: After checks for minimum overall extended data delivery time and load balancing condition, the decision is made.

Step 3: Based on individual loads and minimum total extended data delivery time, attachment points are selected. Or rank 1 is specified when the load is minimum and a minimum total extended data delivery time.

Step 4: The attachment point connecting linearly varies from M_{max} to M_{min}. The formula that decides is,

$$\text{Mobile Nodes(SU) count} = \frac{F_i - F_{Worst}}{F_{best} - F_{worst}} (M_{max} - Mmin + Mmin \quad 5$$

where

F_i : ith fitness of the network

F_{worst} : fitness of the poorest network.

F_{best} fitness of the best network

M_{max} maximum number of SUs

M_{min} minimum number of SUs

Step 5: Subsequent to comparison of the access points' loads and minimum total extended data delivery time of connections of SUs. Such calculations took place for SUs with options of access point with 3 or even more numbers. Then the connection is made with one that has the least load and minimum total extended data delivery time. Usually handoff requesting SUs are connected through attachment points for those with zero mean value and varying values of SD. The following formula is used:

$$\sigma_{iter} = \frac{(iter_{max} - iter)^{n_{NL}}}{(iter_{max})^{n_{NL}}} (\sigma_{initial} - \sigma_{final}) + \sigma_{final} \quad (6)$$

where

$iter_{max}$ maximum iteration user assigned value

iter : present iteration value

$\sigma_{initial}$ *and* σ_{final} initial and final user assigned early SD values

Step 6: Eradicate highly loaded attachment points and the others with high time extended totally for delivering data. Retain them who opt to be least loaded and with a minimum total extended data delivery time.

Step 7: The iterations are done until reaching the best possible optimal fitness value.

4. IMPLEMENTATION OF IWO FOR SUs SPECTRUM HANDOFF

Input Parameter: [Seeds(min), Seeds(max)] = [0,2]
Count of decision variables = 2
Maximum size of population of weeds = 1000

Output Parameter: For selecting the best networks as well as channels. Once the mapping of variables is done, the IWO algorithm goes through modifications for suiting the problem needs to optimize the spectrum handoff. The IWO algorithm in proposal (Figure 2.b) to optimize network loads and to minimize its total extended data delivery time of SUs at the time of handoff. The following are the steps (Ref Figure 2.a):

1. Selecting the Networks as well as channel possibly the best.
2. Utilize fixed or probability scheme to select a channel as well as depending on traffic in the network select network.
3. Compute the fitness of every channel as well as networks depending upon the load of the network (by fixed or stochastic method)

4.1 Compute the load of the network by the equations given as follows: $\ell_i = \sum e_{ij}$ and $_i(X) = \sum e_{ij}$

e=data rate, i= attachment point and j= Mobile node the constraint is, $\ell_i + \gamma_i(X) \le z_i$

4.2 Optimized Fitness Function for Load Balancing:

$$\text{Min} = \sum \left(\frac{\ell \text{i} + \gamma_i(X)}{z_i}\right)^2$$

4.3 Joint optimized Fitness Function

$$G(X, \alpha, \beta) = \alpha\, min\{E[T_{Prob(or)}T_{fixed}]\} - \beta \sum w(i) \left(\frac{\ell \text{i} + \gamma_i(X)}{z_i}\right)^2$$

W(i)= weight factor (Network)

5. Following the order of the least load the attachment points are chosen as well as based on the emptiest period the best channel is chosen.
6. Avoid the networks heavily loaded as well as the channel with a minimal empty period
7. Choose the channel with the emptiest period as well as loaded to the least extent.

5. PERFORMANCE ANALYSIS

The effect of applying the procedures of the new metaheuristic type algorithm of Invasive Weed Optimizing (IWO) to dissimilar channels being modelled at CR networks are mentioned here. Comparing is done with always stay and always change (IEEE 802.22 WRAN) Standards added to random selection strategy. In the strategy where selecting is randomly done, from the central pool one of the channels may be selected which has the same probability. The target channel selecting strategy is additional to the future benchmark that will take place. CR network with a channel number of five with $\mu_{IS}^{(kt)}$= 0.05 for $1 \le k_t \le 5$, t_s =1, n_{max}=10 and *r*=6 is taken for consideration. $\lambda_{IS}$is one as well as the same to each channel; changes are being done from 0.01 as well as 0.032. For non-homogeneous loads, ($\lambda_{se}^{(1)}$ $\lambda_{se}^{(2)}$ $\lambda_{se}^{(3)}$ $\lambda_{se}^{(4))}$ $\lambda_{se}^{(5)}$)= (0.007, 0.02, 0.035, 0.03, 0.01). For homogeneous loads, $\lambda_{se}^{(kt)}$= 0.025 for $1 \leq k_t \leq 5$.

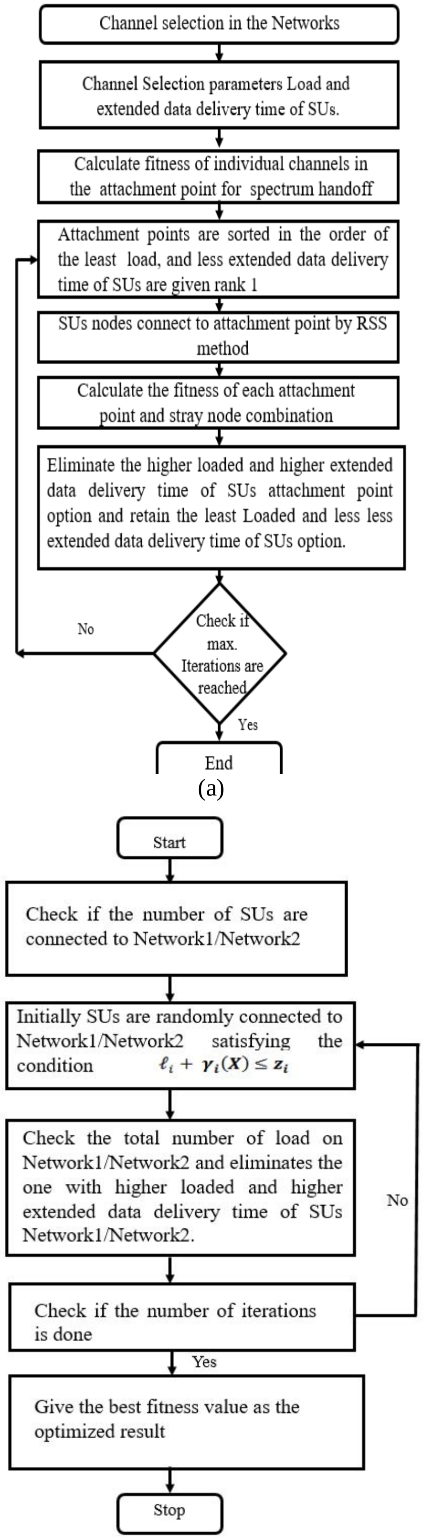

Figure 2: (a) IWO applied to Spectrum Handoff, 2.(b) proposed spectrum handoff decision

But for channels that are not similar, ($\mu_{se}^{(1)}$ $\mu_{se}^{(2)}$ $\mu_{se}^{(3)}$ $\mu_{se}^{(4)}$) $\mu_{se}^{(5)}$) = (0.1; 0.09; 0.15; 0.12; 0.2). The channels of the last case which are identical, $\mu_{se}^{(kt)}$ =0.1 for $1 \leq k_t \leq 5$.

Values of n_{max}as well as r having selected from previous observation results at [5]. Many more parameters than from early study in [4] are also chosen for comparison. Table 1, Table 2, as well as Table 3 respectively are summarizing the GA, PSO and IWO parameters.

Table 1: GA parameters

Generations Count	20000	Population size	2000
Delayed generations limit	500	Elite count	100
Crossover probability (p_c)	0.9	Stalled time limit	∞

Table 2: PSO parameters

Number of iterations	20000	Number of particles	2000
Stalled iterations limit	500	[$pos^{(l)}$ $pos^{(u)}$]	[0.0001 100]
w_{min}	0.3	w_{max}	1
Cognitive coefficient	1	Social coefficient	1

Table 3. IWO parameters

Number of iterations	20000	[$Seeds_{(min)}$, $Seeds_{(max)}$]	[0,2]
No. of decision variables	2	Maximum weed Population Size	2000
[$iwo^{(l)}$ $iwo^{(u)}$]	[0.0001, 100]	Variance Reduction Exponent	3
Initial Value of Standard Deviation	1.5	Final Value of Standard Deviation	0.0001

5.1 Validation of model –analytical type

Simulations for the paper's work for CR network are carried out using MATLAB/ SIMULINK 2016a software. Fig.3 and Fig. 4 shows the simulated results for a dis-similar general channel having loads of homogeneous and heterogeneous networks of CR. Such results validate the mentioned analytical model and ensure that the assumptions are right. The graph shows the implementation of the algorithm of IWO in various fields: the fixed sequence transition matrix R_{fixed} for achieving proactive fixed sequence method optimizing task. Stochastic sequence transition matrix R_{prob} for achieving optimizing proactive stochastic sequence method. The IEEE 802.22, WRAN Standards inclusion to compare performance from [13]. Optimization of Extended Load Balancing Model too is carried out and it reaches very close to the optimized solutions of PSO as well as GA.

From Figure 4, it is clearly observed that the 'Extended data delivery time' of every SU remains high; it is minimal in the method of IWO-PROB. The method of IWO-Prob too yields improved results in comparison with the traditional scheme as there is optimizing of extended data delivery time.

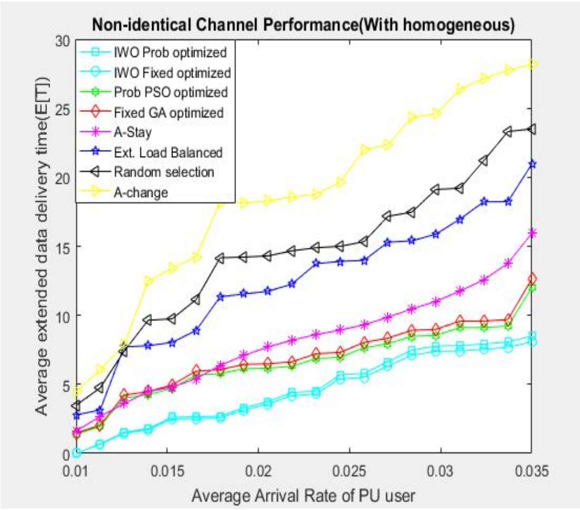

Figure 3: Extended data delivery time performance comparison with inter-arrival time of PU for non-identical channel case with homogenous loads.

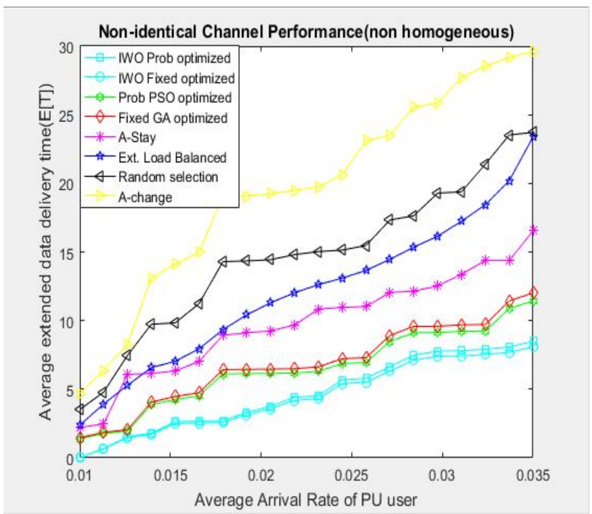

Figure 4: Extended data delivery time performance comparison with inter-arrival time of PU for non-identical channel case with non-homogenous loads.

5. 2 Performance measurement of load

The comparison of load distribution vs covariance of load of the proposed method has been illustrated in Figure 5. It has been observed that for optimizing, IWO algorithm performance is better. This is due to loads being evenly distributed to all attachment points.

$$\text{Covariance (CoV)} \frac{\sum_{i=1}^{P}\sum_{i=P}^{P+Q}(X_i-\bar{X})\,(Y_i-\bar{Y})}{(Q+P)-1} \qquad (7)$$

The proposed algorithm is extensively utilized compared to algorithms of A-change and Fixed-IWO algorithms. The plot in Figure 5 depicts that covariance load decreases when the number of handoff requesting SUs is increases. Also it shows that the Covariance increases for the SSF algorithm. However, the covariance load decreases in the Prob-IWO. The results clarify that the performance of IWO is superior to A-change and Fixed-IWO in particular in vertical handoff problems the primary concern is network load optimizing task. The decrease in the covariance of load indicates that all attachment point has equally distributed load.

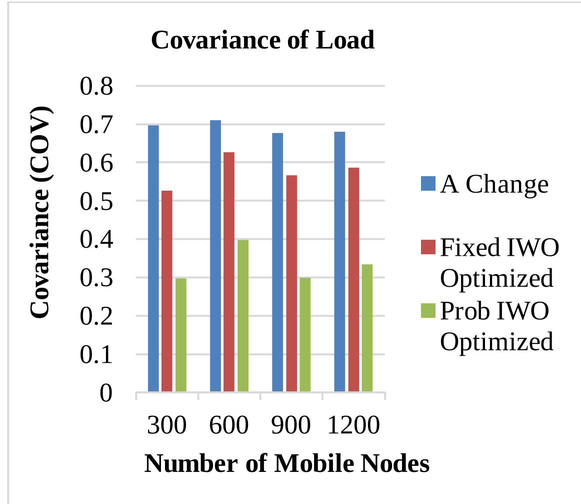

Figure 5: Load distribution for 1200 Mobile Nodes

5.3 Accuracy

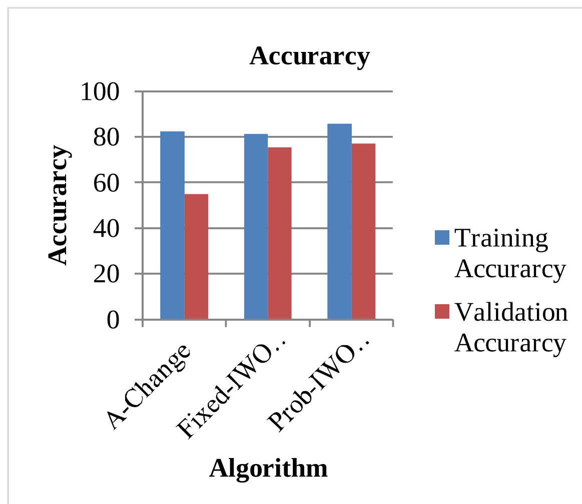

Figure 6: Training and validation accuracy scores

Accuracy of training as well as validating algorithms are shown in figure 6. The optimized prob-IWO scheme had the utmost accuracies at 85.8% as well as 77.2% at the same time A-change had the smallest accurate algorithm for the dataset given. Definition for Accuracy is:

$$Accuracy = \frac{Number\ of\ correct\ predictions}{total\ number\ of\ predictions} \qquad (8)$$

6. CONCLUSION

In this research work, the mathematical model for a CR network's channel that is not identical has been proposed. The (PRP) M/G/1 queueing network is modelling the SUs' extended data delivery period E[T] for analyzing. This model enables evaluating SUs' extended data delivery period E[T] in case of fixed or stochastic transition matrices, utilizing meta-heuristic methods inspired by nature: Particle Swarm Optimization, Genetic Algorithm and IWO inclusive of channels which are not identical having homogeneous or non-homogeneous loads. Also, the validation of the work in the proposal is done by simulations. Selection of target channel methods comparison with each other based on the shown performance by the matrices after doing optimization. After obtaining numerical results, an analysis comparing genetic algorithm, invasive weed as well as particle swarm optimization is done. From the numerical results, it is known that $R_{fixed}$and R_{prob} by optimizing yield results which are similar and in that a scheme that has a proposal to force a selected fast hybrid target channel is available. Compared with IEEE Standards for target channel selection, this proposed IWO method yield good outcomes.

The extension of future work can be carried out as follows. The model can have a service time distributed- to mention it in a general way. It will be by utilizing IWO for selecting the hybrid type (which can adapt to fixed as well as stochastic). The rest of the formulas may be suitably changed for the hybrid method to get still a reduction of extended data delivery time. Various mathematical modelling used earlier and present works will yield good future work. It is presently under study. Research works done till now highlight feasible features of the latest formulae. This can be optimized further; it will lead to network capacity significantly increased extending facility to still more SUs. This is in a situation where the delay constraint parameters which are very strict.

REFERENCES

1. I. Akyildiz, W.-Y. Lee, M. C. Vuran, and S. Mohanty. **A survey on spectrum management in cognitive radio networks**, *IEEE Communications Magazine*, vol. 46, no. 4, pp. 40–48, April 2008. https://doi.org/10.1109/MCOM.2008.4481339
2. S. Zahed, I. Awan, and A. Cullen. **Analytical modeling for spectrum handoff decision in cognitive radio networks**, *Simulation Modelling Practice and Theory*, vol. 38, pp. 98-114, 2013. https://doi.org/10.1016/j.simpat.2013.07.003
3. M. N. Sakib, M. M. Tabassum, M. A. Razzaque, and A. L. Wadud. **An energy-efficient common control channel selection mechanism for Cognitive Radio Ad Hoc Networks,** *Annals of Telecommunications*, vol. 70, no. 1–2, pp. 11–28, February 2015.
4. R. Rath, R. Tamilkodi, K. V. Mishra, and K. J. Cherian. **Utilizing contemporary benchmark protocol for sharing mobile ad-hoc network environment**, *International Journal of Advanced Trends in Computer Science and Engineering*, vol. 7, no. 6, pp. 96–98, 2018.
5. AA.A.M Zahir, S.S.N Alhady, W.A.F.W Othman, Zhiling Low, and A.A.A Wahab. **Genetic algorithm optimization and implementation of velocity control PI controller for cart follower application**, *International Journal of Advanced Trends in Computer Science and Engineering*, vol. 8, no. 5, pp. 1886–1892, 2019.
6. L. C. Wang, C. W. Wang, and C. J. Chang, **Optimal target channel sequence design for multiple spectrum handoffs in cognitive radio networks.** *IEEE Transactions on Communications*, vol. 60, no. 9, pp. 2444–2455, September 2012.
7. C. W. Wang and L. C. Wang. **Analysis of reactive spectrum handoff in cognitive radio networks**, *IEEE Journal on Selected Areas in Communications*, vol. 30, no. 10, pp. 2016–2028, November 2012. https://doi.org/10.1109/JSAC.2012.121116
8. A. D. Domenico, E. Strinati, and M. D. Benedetto. **A survey on mac strategies for cognitive radio networks**, *IEEE Communications Surveys Tutorials*, vol. 14, no. 1, pp. 21–44, 2012.
9. F. Sheikholeslami, M. N. Kenari, and F. Ashtiani. **Database query optimization using genetic algorithms: A systematic literature review**, *International Journal of Advanced Trends in Computer Science and Engineering*, vol. 8, no. 5, pp. 1903–1913, 2019.
10. L. C. Wang, C. W. Wang, and F. Adachi. **Load-balancing spectrum decision for cognitive radio networks**, *IEEE Journal on Selected Areas in Communications*, vol. 29, no. 4, pp. 757–769, April 2011.
11. A. Zakariya, A. Tayel, and S. Rabia. Comments on **Optimal target channel sequence design for multiple spectrum handoffs in cognitive radio networks**, *IEEE Transactions on Communications*, vol. 63, no. 8, pp. 3021–3024, Aug 2015. https://doi.org/10.1109/TCOMM.2015.2450209
12. F. Mina, and A. Ghasemi. **Analysis of the PRP M/G/1 queuing system for cognitive radio networks with handoff management**, *in Proc. 2014 Iranian conference on electrical engineering*, 2014, pp. 1047-2014.
13. C. Cordeiro, K. Challapali, D. Birru, S. Shankar N. **IEEE 802.22: An Introduction to the first wireless standard based on cognitive radios,** *Journal of Communications, vol. 1, no. 1, April 2006.* https://doi.org/10.4304/jcm.1.1.38-47