Spectrum Allocation of Cognitive Wireless Network based on Immune Clonal Optimization Algorithm

Hean LIU, Haogui CHEN, Zhike KUANG
Hunan City University, Yiyang, Hunan, 413000, CHINA

Abstract: With the continuous innovation of wireless communication technology and new business emerging, the spectrum allocation requirements have also increased. The traditional static spectrum allocation and the low utilization rate of radio network has been unable to meet the growing, there are defects, in order to solve a series of problems, put forward the research of cognitive radio spectrum allocation algorithm in intelligent network based on the immune clonal optimization. Firstly, the spectrum sensing and spectrum allocation for cognitive radio networks are modeled, and then the immune gene cloning algorithm and Realization of algorithm analysis, finally to immune modeling experiment, using MATLAB7.0. The results show that the algorithm is able to ease the contradiction between the growing demand for wireless services and limited the spectrum resources, reduce the complexity of the algorithm, improves the spectrum allocation effect, which has practical value.

Keywords: Immune clone; Multi intelligence algorithm; Spectrum allocation; New model

1. Introduction

With the development of wireless communication, new technology and new business emerging, demand will show a rapid growth index spectrum. And the spectrum of wireless power grid like natural gas, oil, is a non- renewable resources, it is because of the lack of renewable energy is a valuable point of the radio spectrum, and the spectrum of this non-renewable resources, there is a shortage of [1-3]. On the basis of radio network frequency division, radio spectrum can be used at present, the use range is narrow, the new growing wireless cannot meet communication business and new technology business needs, the needs of the frequency index increased rapidly. But due to the traditional static spectrum distribution of the defect, and has left the future of the new spectrum system and technology business is less, plus its particularity is not renewable, have to face the future no problem spectrum can be assigned.

Spectrum allocation problem is often a complex optimization problem, and the traditional mathematical optimization algorithm is more complex. In the circumstances, how to effectively use the immune clonal algorithm in cognitive radio networks for spectrum allocation has become a hot issue of the [4-6]. Found in the Berkeley Wireless Research Center Research Report, the traditional spectrum utilization rate is very low, a lot of spectrum resource has not been fully utilized because of some without [5-7]. Authorized band busy, occupancy or some support, even in the global spectrum, good signal propagation characteristics of low frequency, the utilization rate is still low. So how in the cognitive wireless cyber source limited conditions to improve the allocation of spectrum utilization, in order to alleviate the contradiction between the growing demand for wireless services and Co. the spectrum resources, has become a top priority in the field of communication [8-9].

The traditional wireless network technology has low utilization rate of defects, and cognitive radio network technology compared with the traditional, has several unique advantage, can greatly improve the spectrum allocation efficiency in the use of cognitive radio network technology. The system equipment has sensing function, if they do not interfere with the normal communication of the user authorization, parameter detection around the smart wireless environment and adaptively adjust its data link layer and physical layer varies with the change of the surrounding environment, intelligent sensing to detect spectrum holes to communicate, so as to solve the time delay, data rate, and other expenses. Reducing the economic burden of spectrum management organization, improve the quality of user service and to meet the needs of users, greatly improve wireless spectrum efficiency. The rational use of flexibility and adaptability. Fundamentally solve the traditional cognitive some problems such as static equilibrium spectrum allocation policy line grid technology in use. In the condition of limited wireless resources by improving the spectrum utilization rate to effectively alleviate the contradiction between supply and demand of limited spectrum resources and the rapid growth of wireless business needs.

In order to solve a series of problems, put forward the research of cognitive radio spectrum allocation algorithm of intelligent network based on immune clonal optimization. Firstly, the spectrum sensing and spectrum allocation of cognitive wireless network is modeled on immune gene cloning algorithm. Algorithm analysis and implementation, to carry out the final immune modeling experiment, using MATLAB7.0 results show that the algorithm is able to ease the contradiction between the growing demand for wireless services and the limited spectrum resources, reducing the complexity of the algorithm, improves the spectrum allocation effect, and to provide a theoretical basis for further research and implementation, has a certain reference value.

2. Modeling of Spectrum Sensing and Spectrum Allocation in Cognitive Radio Networks

In cognitive radio network, the main function of the physical layer spectrum sensing algorithm is to determine whether there is a main user in the communication range by monitoring the signal of the transmitter of the main user, so as to determine the free spectrum. Since this paper mainly solves the problem of how to allocate the spectrum, the paper combines the characteristics of IEEE 802.22 wireless local area network, and uses the two phase detection method for spectrum sensing.

If in a region $i \in [(m-1)\tau, n]$, a I N primary users and secondary users random distribution, the spectrum was divided into M completely orthogonal frequency band, the secondary users in order to meet the demand of spectrum allocation rules, the performance of different points of each spectrum, can also use multiple spectrum. Assuming that the interference between users is determined by the distance between their geographic location, the main user and the secondary user use an omnidirectional antenna. For each of the wireless spectrum, the main user corresponds to a coverage area, this area is the main user as the center, that a circular area covering radius. If the secondary user in this coverage area and the use of the same spectrum of the main user, the main users will be generated interference, resulting in transmission failure. For secondary users, it also has a disturbance in each region of the spectrum $X(i)$, this area is the primary user interference as a center, a radius of circular area $f : \mathbf{R}^m \to \mathbf{R}$. The secondary user can use the same spectrum with the primary user when the interference range of the secondary spectrum is not overlapped with the coverage of the primary user. By adjusting its power to interfere with the radius of the user, to avoid conflicts with the main user. At the same time, if 2 users in a spectrum of interference areas overlap, then they can use the spectrum at the same time, and the definition of these 2 users in the spectrum for the neighbors. Assuming that all primary and secondary users are using the same power, the coverage area of all the primary and secondary users is the same as the radius. As shown in Figure 1.

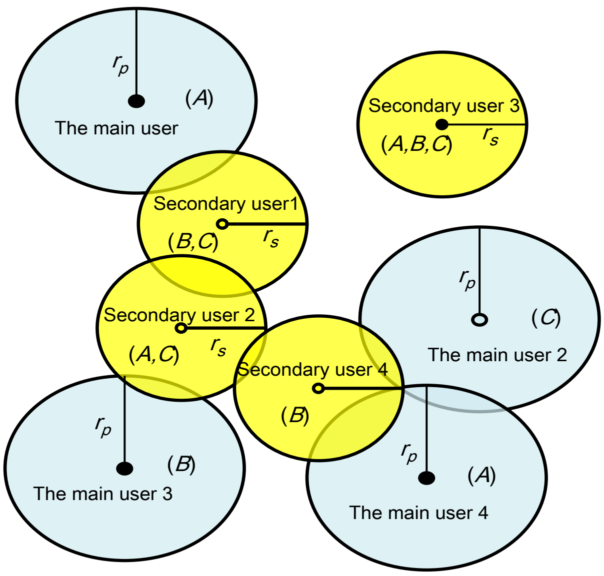

Figure 1. Coverage topology of cognitive wireless networks

In the cognitive radio network application environment, the topology of the network will change with the change of environment, which can be obtained by the detection report of each cycle of the system. Because the time of spectrum allocation of cognitive radio network system is very short, it is assumed that the system topology structure will not change.

3. Immune Clonal Optimization Algorithm

Specific Implementation of Spectrum Allocation based on Immune Clonal Selection Algorithm.

This spectrum allocation problem is described as: in the available spectrum matrix L efficiency matrix B interference matrix C known, how to find the optimal spectrum allocation matrix A, making the network efficiency $Self_{\text{variation}}$ maximum.

In this paper, we design a wireless cognitive network spectrum allocation algorithm based on immune clone algorithm. The basic steps are as follows: G () represents the antibody population, and the M represents an antibody.

3.1. Initialization

Set an evolutionary algebra G is 0, random initialization of the population $x_i \in D(i \geq 1, i \in N)$, which, (U) size s said the size of the population. At the same time set up the memory unit $D = \{0,1\}^l$, the size of the size of T, the initial is empty. Using binary code, the length of each antibody is $Self \subset Ag$, that is, l is the number of elements in the available spectrum matrix $Nonself \subset Ag$, and each antibody represents a possible spectrum allocation scheme. At the same time, the records of the matrix L value of 1 elements corresponding to the N and m, and according to the first n increments, after the way to increase the m in 1 L, that is, $Self \cup Nonself = Ag$. Obviously, the number of elements in the 1 L is L.

3.2. Interference constraint handling

The allocation matrix A is modified, the requirements must meet the interference matrix C, the specific implementation process is as follows: for any m, if the $Self \cap Nonself = \varphi$, then check the matrix A in the column n of the first m and line k elements are 1. If it is, then the random will be one of the 0, the other remains unchanged. At the same time, the distribution matrix A is obtained as a feasible solution of the constraint processing. At the same time, the corresponding antibody representation is mapped to update $x_i \in D(i \geq 1, i \in N)$.

Immature antibody must undergo self tolerance to be converted into mature antibody. Because the Self is dynamic, the tolerance process is dynamic.

The kinetic equation of self tolerance is defined as:

$$f_{match}(x,y)=\begin{cases}1,\begin{Bmatrix} iff\,\exists i, j(x.d_i=y_i, x.d_{i+1}=y_{i+1},\ldots\ldots, x.d_j=y_j, \\ j-i\geq r, 0<i<j\leq l, i, j, r\in N) \end{Bmatrix} \\ 0, otherwise \end{cases} \qquad (1)$$

$$Self(t)=\begin{cases}\{x_1, x_2, \ldots x_n\},\ t=0 \\ Self(t-1)-Self_{dead}(t) \\ -Self_{variation}(t)+Self_{new},\ t\geq 0 \end{cases} \qquad (2)$$

$$Self_{variation}(t)=\{x\,|\,x\in Self(t-1), \exists y\in B(t-1)\wedge f_{match}(x,y)=1\} \qquad (3)$$

3.3. Antibody representation to the mapping of spectrum allocation scheme

The population of each antibody $Ag \subset D$ each $Self \cap Nonself = \varphi$ mapped to the elements of the matrix $Self \cap Nonself = \varphi$, $Ag \subset D$, which, the value of 1L $Self \cap Nonself = \varphi$ in the corresponding J element $x_i \in D(i \geq 1, i \in N)$. At this time, the corresponding distribution matrix A is a possible spectrum allocation scheme.

3.4. Pain P G affinity function evaluation

As the goal of spectrum allocation is to maximize the network $D=\{0,1\}^l$, this paper directly will (U) UR as the affinity function. (U) g s antibody affinity calculation, according to the results from the size and sort descending, before the high affinity (U) TT s < antibody to have unit (s) u M g update (if the memory cell is empty, then put t into antibody (s) u M g, otherwise, in accordance with the pro and force for the replacement, to ensure the highest fitness value of individual T memory preservation unit). As a result, the distribution matrix A of the u g of the memory unit (s), which is the largest of the affinity of the M, is the optimal spectrum allocation scheme.

3.5. Termination condition judgment

If the maximum number of $Self_{dead}$ is reached, the algorithm terminates, and the highest affinity antibody is mapped to the A form, which is the best frequency spectrum allocation; otherwise, the step 4.

4. Simulation Experiment and Result Analysis

Simulation of some primary and secondary users in a fixed range system, so that each user can master from the pool of available in the intelligent spectrum to choose to communicate their own spectrum, and choose a position given to the primary users, and each time the user to adjust the scope of power and interference (M, N) SRNM to avoid interference with the primary user. Assuming that the interference radius is fixed, the network topology of the 53 randomly generated network is calculated.

Parameter Setting in Immune Clonal Selection Algorithm. After repeated tests, the immune clone selection in the spectrum allocation calculation parameters are as follows: the maximum Max g =200 evolution; population size S = 20, TS = 0.3 the size of the memory unit; the control parameters of 50 TN clones =1, 0.2L (L = 0 similarity threshold for binary antibody encoding length); 0.1 M P =0 mutation probability.

Algorithm in XP Windows environment, the use of MATLAB7.0 programming. The experimental results were measured by MSRM, MMR and MPF. In order to verify the performance of the proposed algorithm, compared with the current solution of CSGC and GA-SA two classical algorithms are compared and analyzed, the comparison test using the same L, B, C, and the algorithm runs 53 times, take the average results. The results are shown in Figure 2, 3.

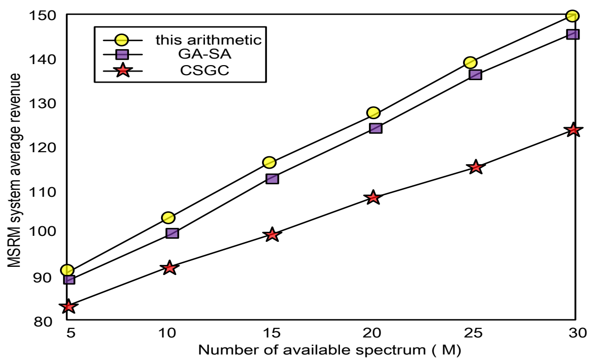

Figure 2. The influence of available spectrum on correlation algorithm MSRM

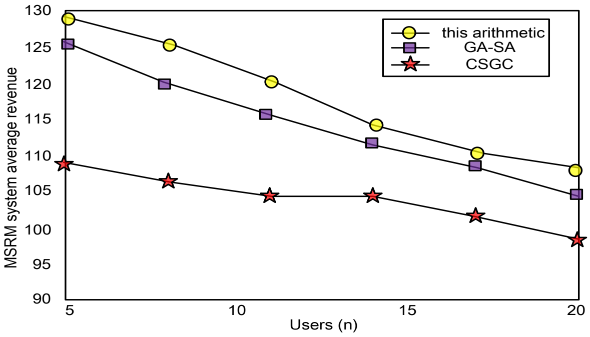

Figure 3. The impact of the number of users on the correlation algorithm MSRM

From Figure 3 and Figure 4 results, we can see that the use of optimal immune clonal optimization algorithm, the relative error rate is smaller. In the use of the algorithm after 100 times of calculus, evolutionary value to 200 generations, and has optimal spectrum allocation solution is very close, basically can directly find the best the solution, further proved the accuracy and effectiveness of the algorithm.

4. Conclusions

With the development of communication network, in cognitive radio networks, how to change the traditional static spectrum allocation with low defect rate, to achieve access to the key technologies of dynamic spectrum sensing. The calculated spectrum itself is a complex process, and the use of immune clonal optimization algorithm can solve the problem of optimization is a new model of spectrum allocation and. This paper presents research on Intelligent Algorithm of spectrum allocation model based on immune clonal optimization, in the experiment, the algorithm and the CSGC algorithm are compared, GA-SA performance simulation. The simulation results show that the algorithm can achieve the maximum efficiency of spectrum allocation, and it also has a good convergence, and it is of great significance.

Acknowledgment

The work is supported by scientific research project of Hunan Education Department (15C0255).

References

[1] R. Berangi, S. Saleem, M. Faulkner, et al. TDD cognitive radio femtocell network (CRFN) operation in FDD downlink spectrum. IEEE, 22nd International Symposium on Personal, Indoor and Mobile Radio Communications, 2015: 482-486

[2] CAMILLE C, XAVIER B, LAURENT N, et al. Surface reconstruction using power watershed[C]//International Symposium on Mathematical Morphology, Verbania-Intra, Italy: ACM Press, 2015: 381-392.

[3] Timmis J,Andrews P,Owens N,et al.An interdisciplinary perspective on artificial immune systems. Evolutionary Computatio n,2013;1:5-26.

[4] Kim J,Bentley PJ,Aickelin U,et al.Immune system approaches to intrusion detection-a review.Nat Comput,2014;6(4):41-66.

[5] Xu, Z. Y. Feng, Y. Z. Li, et al. Fair Channel allocation and power control for uplink and downlink cognitive radio networks. IEEE., Workshop on mobile computing and emerging communication networks, 2015:591-596

[6] W. Q. Yao, Y. Wang, T. Wang. Joint optimization for downlink resource allocation in cognitive radio cellular networks. IEEE., 8th Annual IEEE consumer communications and networking conference, 2015:664-668

[7] S. H. Tang, M. C. Chen, Y. S. Sun, et al. A spectral efficient and fair user-centric spectrum allocation approach for downlink transmissions.IEEE., Globecom.,2011:1-6

[8] Muhammad J. Mirza, Nadeem Anjum. Association of Moving Objects across Visual Sensor Networks. Journal of Multimedia, Vol 7, No 1 (2016), 2-8

[9] Zhao Liangduan, Zhiyong Yuan, Xiangyun Liao, Weixin Si, Jianhui Zhao.3D Tracking and Positioning of Surgical Instruments in Virtual Surgery Simulation. Journal of Multimedia, Vol 6, No 6 (2016), 502-509