Themed Section : Engineering and Technology
© 2018 IJSRSET | Volume 5 | Issue 3 | Print ISSN: 2395-1990 | Online ISSN : 2394-4099

Fuzzy C-Means Clustering based Dynamic Spectrum Allocation in Mobile Communication

Ganesan R[1], Pradeep S[2]
[12]Assistant Professor, Department of ECE, Bharathiyar College of Engineering & Technology, Karaikal, Puducherry, India
ganesanr.ece@gmail.com[1], s.pradeeponline@gmail.com[2]

ABSTRACT

In mobile networks, the efficiency of a point-to-point communication link has several limitations. The only way to improve the network capacity is by node density. This research discusses similar issues in current LTE macro based system. In existing system, the spectrum efficiency utilization is made by handling the traffic for indoor users to reduce the load on macro cells. Traditionally, the Dynamic Spectrum Allocation (DSA) aims to increase the capacity and to reduce the interference by (de)activating the available LTE frequency carriers. To avoid such issues we need to allocate the spectrum dynamically with respect to the user demand. To implement this several current survey is made and a new spectrum allocation is proposed. It is based on evaluating the DSA potential of achieving some improvement and to identify the traffic conditions. In this proposed scheme, the spectrum sharing has processed and identified throughout by using Fuzzy C-Means (FCM) clustering algorithm. It is named as Fuzzy C-Means Clustering based Dynamic Spectrum Allocation (FCM-DSA). The experimental results prove that the proposed scheme attains maximum throughput of 105Mbps when comparing with traditional adaptive co-existence spectrum sharing schemes.

Keywords: Mobile Communication, Macro Cells, Spectrum Allocation, Spectrum Sharing, Fuzzy C-Means Clustering

I. INTRODUCTION

A large majority of the algorithms were developed for networks based on the demand. Nowadays the process is combined with the multiple applications on a single IP-based infrastructure with high Quality of Service (QoS). In addition to that, there is a need to satisfy end-users' Quality of Experience (QoE). To satisfy this process, Third-Generation Partnership Project (3GPP) is used to represent the QoS framework for Long Term Evolution (LTE) based networks. Since, the problems exist due to the some demand made by the user such as data rate and bandwidth. This type of processing may results in pushing the researchers to think about some intelligent techniques. Hence, during network congestion the Mobile Network Operators (MNOs) need to think about some techniques to manage network traffic in the transport layer. Tabany and Guy (2015) solved this issue by implementing a new Delay-Aware QoS Scheme (DAQS). Since, the problem exists such as complexity and performance degradation.

The reliable data transmission is important in various aspects such as quality of-service requirements. Mostly the communication network provides effective way in many applications such as content sharing, video streaming and mobile multimedia communications. When analysing wireless applications the task is critical because also gets increased inters of channel variation, system robustness and interference.

Traditionally, the 3GPP has introduced LTE macro cells to handle the traffic for indoor users and to reduce the load on the Macro cells. But still these processes have some limitations on current LTE macro based system. For Mobile Network Operators (MNOs) it is critical to use the LTE spectrum assets, as well as the installed network infrastructure, in the most cost efficient way.

The main contribution of this method is spectrum sharing based on the macro cell capacity, then it is processed and its capacity is identified and grouped between the cells with the help of FCM. It results in the improvement in network capacity and performance.

The main objective of this research is to improve the performance, lifetime and minimize the energy. These processes are made by Fuzzy C-Means (FCM) clustering algorithm based spectrum sharing. The main advantages of this method is

- It is efficient for overlapped data set.
- In FCM the data point is assigned to each cluster center, this may results in utilizing the data point to more than one cluster.

This research investigates the potential gain from DSA for a LTE macro-cellular network covering a geographical area with Fuzzy C-Means based non-uniform spatial traffic distribution. The remaining of the paper is organised as follows. Some existing methodologies are illustrated in Sect. 2. The problem identification is made in the section 3. The potential DSA performance and its overall process are described in section 4 as research model. The evaluation of the proposed FCM based optimised DSA algorithm with traditional adaptive Co-existence spectrum allocation is made in the section 5. Finally, the paper is summarized in the section 6.

II. LITERATURE SURVEY

Hu and Qian (2014) explored a system framework of cooperative green heterogeneous networks for 5G wireless communication systems. Initially, they made a survey about Spectrum Efficiency (SE), Energy Efficiency (EE), and Quality of Service (QoS) based mobile association and power control. They also presented the system framework of cooperative green heterogeneous networks. Their major objective is to balance and optimize the SE, EE, and QoS in heterogeneous wireless networks.

In cellular and future communication systems, the flexibility and efficiency is improved by using Multi-Input Multi-Output Orthogonal Frequency Division Multiplexing (MIMO-OFDM). Patel et al., (2016) presented a resource Allocation Problem for spectrum sharing in wireless communication system with key element energy efficiency. They proposed an algorithm that process subcarrier and power allocation simultaneously under data rate constraint.

Bao and Liang (2014) studied joint spectrum allocation in heterogeneous cellular networks with several base stations. For this concept they applied the geometric approach to derive the average downlink user data rate in a closed-form expression. They combined the optimizing spectrum allocation and user association in order to solve the optimization problem. A computationally efficient Structured Spectrum Allocation and User Association (SSAUA) are designed. If the density of users is low then there is performance degradation. A Surcharge Pricing Scheme (SPS) is represented here to make Nash equilibrium. They compared the SSAUA approach with the SPS.

Christodoulopoulos et al., (2013) considered the problem of serving traffic in a spectrum-flexible optical network. Here the problem is identified in the spectrum allocation. While allocating the spectrum an end-to-end connection may change to adapt the time-varying transmission rate. While considering the route with appropriate Routing and Spectrum Allocation (RSA) algorithm, the spectrum utilizes around the reference frequency to expand and contract to match source rate fluctuations. They proposed and analyzed the three Spectrum Expansion/Contraction (SEC) policies for modifying the spectrum allocated to each connection.

Velasco et al.,(2014) solved the routing and spectrum allocation related optimization problems with the help of Off-Line to In-Operation Flexgrid Network Planning. Chatterjee et al., (2015) focused on different node architectures, and compare its performance in terms of scalability and flexibility. They reviewed and classified the Routing and Spectrum Allocation (RSA) approaches with some merits and demerits. It includes various aspects, namely, fragmentation, modulation, survivability, energy saving and networking cost.

With the recent developments, the spectrum aggregation is introduced by 3GPP with LTE-advanced standard. Hence, the LTE-A needs some update function to enhance the features of the carrier aggregation. Lee et al., (2014) reviewed some techniques based on the challenges.

Pai et al., (2016) made a Game Theoretic Optimization of Spectrum Allocation in Cognitive Radio. They have been used the energy detection, it is a spectrum sensing method that detects the presence or absence of a signal by measuring the received signal power. It is used for solving the complex problems and identifies the practical issues. It is noticed that the imperfect knowledge of the noise power results in unwanted detection. Hence to avoid these issues the perfect method is to be needed.

Huang et al., (2016) analyzed the system model of the cognitive radio network based video monitoring system. Here, the cognitive radio network is introduced into the wireless video monitoring system to improve the spectrum utilization. In some conditions the cognitive radios have disabled the interference to licensed users. Initially, they recalled the concept of wireless video monitoring system and then the centralized cooperation spectrum is made with the sensing algorithm. Then the priority and channel ranking is made with the help of the spectrum allocation algorithm.

Akyildiz et al., (2006) made a detail survey about dynamic spectrum access approaches. They listed several challenges and some complex problems. Leaves et al., (2001) focused on spatial and temporal DSA in a multi radio network consisting of a Universal Mobile Telecommunications Service (UMTS) and Digital Video Broadcasting-Terrestrial (DVB-T) system. They made a temporal DSA based load prediction. Finally, the perfect and imperfect load predictions are compared to show that DSA has 30% higher spectrum efficiency compared to fixed channel assignment. Rodriguez et al. (2006) extends the previous DSA concept with spectrum bidding which is formed as different cells from the participating DVB-T and UMTS systems. Further, Kovács and Vidács (2006) proposed a spatial and temporal DSA where called Regional Spectrum Brokers (RSB) coordinates the temporal DSA. The RSB solves the spectrum assignment problem with the help of integer linear programming to reduce the interference.

Hoffmann et al., (2015) evaluated the Self-Optimised Network (SON) based on DSA algorithm. Madan et al., (2010) proposed new paradigms for design and operation of such heterogeneous cellular networks. It focussed on cell splitting, semi-static resource negotiation on third-party backhaul connections and range expansion. It also manages the fast and dynamic interference management for QoS through the-air signalling. Finally, they represented DSA is made with simple, lightweight and extremely low overhead.

III. PROBLEM STATEMENT

In the real time wireless technology or a wireless system the environment parameters changes may be permanent to communicate efficiently by avoiding the interference with the users. Some ancient strategies square measure created to assign the spectrum with many objectives like Spectrum utilization potency Degree of quality and Distance from primary user to the secondary users. The DSA is a process of allocating different dynamic frequency channels that are encountered in many communication systems. Since in adaptive co-existence spectrum the main purpose is to make LTE allocate time resource adaptively based on the traffic load of WLAN system. It is necessary to improve the throughput of the spectrum allocation models. In this research, we made a comparison for FCM based DSA and adaptive co-existence spectrum to verify the effectiveness.

IV. RESEARCH MODEL

A. Adaptive Co-existence Mechanism

Before entering in to adaptive co-existence methodology, the following details are needed. The LTE varies with several categories when comparing with the LAN. It is processed by allocating the bandwidth resources on physical medium. The major difference between LTE and Wireless Local Area Network (WLAN) is that LTE just reduces its transmission speed while WLAN holds its transmission in the case of channel interference. The wireless local area network could be a competition primarily based system and relies on Carrier Sense Multiple Access with Collision Shunning (CSMA/CA), that is, terminals and Access Points (AP) contend along for an equivalent band. If the LTE and local area network deployed in an exceedingly same frequency then the considering the distinction in bandwidth allocation, the bulk of a network/WLAN/wireless fidelity/ WiFi nodes square measure probably to be blocked by LTE once LTE and local area network networks are deployed within the same waveband as a result of LTE interference levels are typically higher than the brink that local area network uses to work out whether or not the channel is idle. Therefore, medium access controls (MAC). The adaptive Co-existence algorithm is shown in the figure 1:

Input: Calculate the ratio during reallocation cycle named as $T_c > 0$ and maximum instant.
Output: LTE sub-frame configuration modes
if (condition) then
LTE spares single sub-frame to WLAN
else if (condition) then
:
:
end if

Figure 1. Adaptive Co-existence Algorithm

From the algorithm, it is noticed that the adaptive co-existence algorithm deals with the selection of LTE frames. It is totally depends on the sub frames with several nodes. Xing et al., (2015) investigated the research with the help of selecting an initial LTE carrier deployment within the allocated spectrum. They have utilized the typical European LTE operator with 20MHz spectrum available in the band of 1800MHz. In terms of evaluating the DSA nodes the investigation is based only on the two scenarios namely, a hexagonal cell layout and a site-specific urban cell layout. In these conditions, they made a traffic hotspot cell which is called as one macro cell at the middle of the investigated area. Based on the cell density the process is made with the hexagonal layout were chosen that may proves the similarity between site specific network under several areas. The inter-site distance within the hexangular layout was chosen such the ensuing cell density is analogous to the one within the site-specific network layout within the thought of space. In many cases, the requested traffic from the users is considered within the network, because the offered traffic to the network. The offered traffic levels within the hotspot cell and also the encompassing cells square measure varied consistent with abstraction traffic intensity maps that square measure scaled otherwise among the hotspot cell and also the encompassing cells so as to come up with totally different load ratios and interference things to the world served by the hotspot cell. During this process the traffic intensity maps the value with some of the assumed characteristics and resulted in minimum throughput. To make the system effective the bounded interval is managed and processed with the help of the cell alignment. It is one of the methods that use different networks to co-exist within the same radio spectrum. The simple example of Co-exist spectrum allocation is digital televisions.

The traditional dynamic spectrum allocation is processed by activating the cell. It is triggered under high load condition. Here, the value is assumed as pre-configured cells. The cells are separated with the help of the cluster information. It is assumed that each cell has a preconfigured Cluster of interfering cells. For adaptive allocation they considered some hotspot cells to coordinate the cluster. In these cases, the high capacity cells are processed or grouped in one group and other low capacity cells are grouped as another one. The high capacity cells are mostly used for spectrum sharing.

B. Fuzzy C-Means Clustering

Dunn (1973) initiates the FCM and further it is modified according to the application. Bezdek et al., (1984) extended the k-means algorithm to Fuzzy C-Means Clustering algorithm. Normally, the Fuzzy C-means is checked by assigning the membership value to each data point which is equivalent to each cluster centre. In fuzzy based set the process is carried through the distance between each cluster with respect to the data point. If the data rate is high then there is number membership value towards the particular cluster center. From the equation it is noticed that the summation of membership of each data point should be equal to one. With respect to the iteration the location of the cluster head is updated as mentioned in the equation. In fuzzy clustering, the clustering process is made by allowing the cell to be a member of any cluster. The objective function for clustering is represented below.

$$Obj(\mathrm{X},\mathrm{Y}) = \sum_{iw=1}^{n}\sum_{jw=1}^{c}\left(\mu_{iwjw}\right)^{m}\left\|x_{iw} - v_{jw}\right\|^{2} \tag{1}$$

Where obj is defines the objective function , X = (μij)n*c is the fuzzy membership matrix, $n \rightarrow$ number of cells, $c \rightarrow$ the number of cluster center, $\mu_{iwjw} \rightarrow$ the membership of iw^{th} cell to jw^{th} cluster center, $m \rightarrow$ the fuzziness index m € [1, ∞], $\left\|x_{iw} - v_{jw}\right\|$ →the Euclidean distance.

With a certain degree of membership the feature vector assign to a centroid and features be inclined to overlap. Initially, the centroids are chosen randomly. So, various initial centroids generate various results and these make FCM to be sensitive to initial centroids. Through an iterative process, the objective function value can be attained where membership and cluster centroids are updated according to given below equations

$$\mu_{ij} = 1/\sum_{k=1}^{c}\left(\frac{d_{ij}}{d_{ik}}\right)^{\left(\frac{2}{m-2}\right)} \tag{2}$$

$$v_j = \frac{\sum_{i=1}^{n}\left(\mu_{ij}\right)^{m} x_i}{\sum_{i=1}^{n}\left(\mu_{ij}\right)^{m}}, \forall j = 1,2,..,c \tag{3}$$

C. Proposed FCM based Dynamic Spectrum Allocation

By means of combining the traditional methods namely, k-means and fuzzy, many researchers were focussed and implemented it in the clustering concepts. In that FCM is termed as the best method because it has best result for overlapped data set. The FCM process is considered for spectrum allocation because the clustering is efficient and similar to that the channels are randomly deployed. The main motive of this clustering is to select the proper channel and initiate the exact slot by satisfying the application module requirement. The algorithm is illustrated below:

Input: Initialize a set of N cell capacity from network
Output: C- Clusters formation

Membership value initialized for cells.
Calculate the vectors

$$C^{(k)} = [c_j] \; with \; U^{(k)}$$

Compute the fuzzy centroid
Update the fuzzy membership value as

$$U^{(k)}, U^{(k+1)}$$

check If updated membership value < previous membership value stop, else
Return to initialization.
Repeat until the centroid no longer move

Figure 2. Algorithm for proposed FCM based DSA

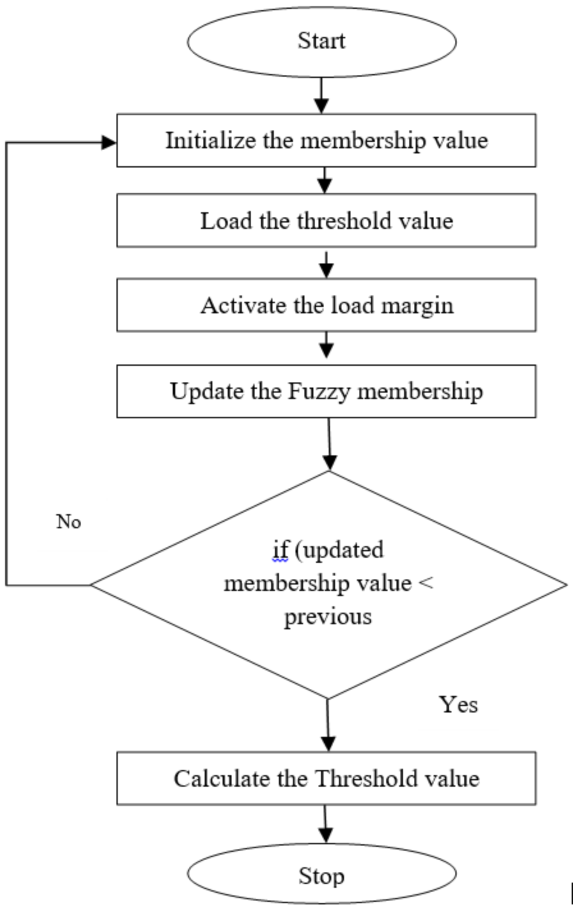

Figure 3. Flow chart for Proposed Fuzzy C-Means based Dynamic Spectrum Allocation

The FCM algorithm is considered here to activate the spectrum allocation with respect to the congested nodes. It is initially, starts with the concept of load threshold activation. The selections of cells are considered here with respect to the level of the bandwidth level. The main advantage of this method is, it faces more challenges and results in the maximum load level with high throughput. The neighbour node or a cell gives the exact location of the spectrum. The process of FCM in allocation is based on the load levels of the neighbour node update value.

There is a need for activating the load value with respect to the threshold activation. While looking it into the cell perspective, the threshold value deals with this concept and process it through the nearby nodes. If the threshold value of the cell is low then the cell allows its cluster neighbours to enable higher bandwidth configurations. While looking it in the cluster based approach, the maximum load among the cell is fixed with the neighbours cluster information.

The main objective of spectrum allocation is to manage the spectrum in a radio system. It shares the radio networks over space and time, to increase overall the spectrum efficiency. In traditional methods the DSA is compared with the absence of cluster throughput with the hexagonal layout and uniform traffic intensity. If the coverage is to long then the cell sizes will be varied with respect to the hexagonal layout.

V. Experimental Result

The evaluation of Dynamic spectrum allocation is important to verify the functionality and its characteristics. The overall evaluation is made in MATLAB. Here the green colour nodes are congested users with 25 users. While red color indicates the non-congested users, which is less than the 25 users. Figure 4 shows the initialization of users under random process. It helps to allocate the spectrum sharing resources. Under different load situations, the neighbouring cells and the hotspot cell can result in some interference situations. It is used her to increase the system performance level. The neighbouring nodes are represented with respect to the carried traffic levels to manage the users. With different iterations, the channels are represented in the figure 5. Furthermore, the optimal FCM-DSA configuration depends only on the traffic ratio between the surrounding cells and the hotspot cell. The figure 6 results show that DSA can provide significant gains only in non-uniform traffic distributions.

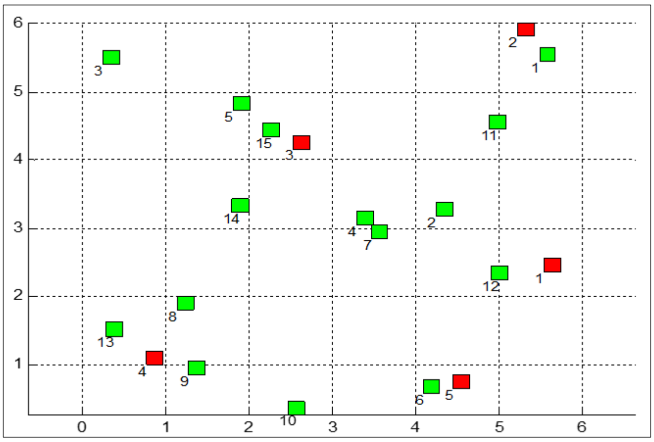

Figure 4. Initialization of Channels

- Congested Channel

- Non Congested Channels

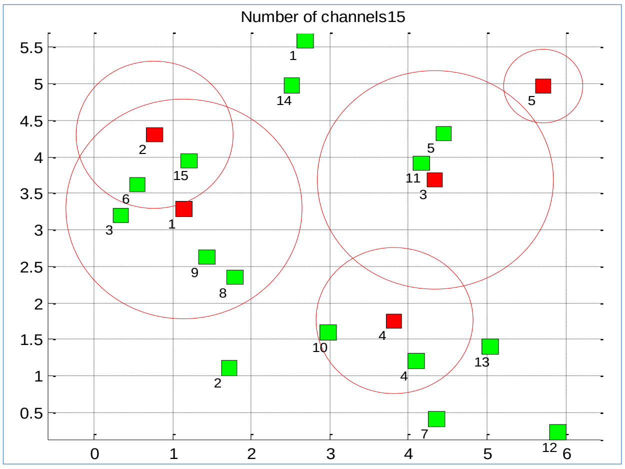

Figure 5. Representation of Channels

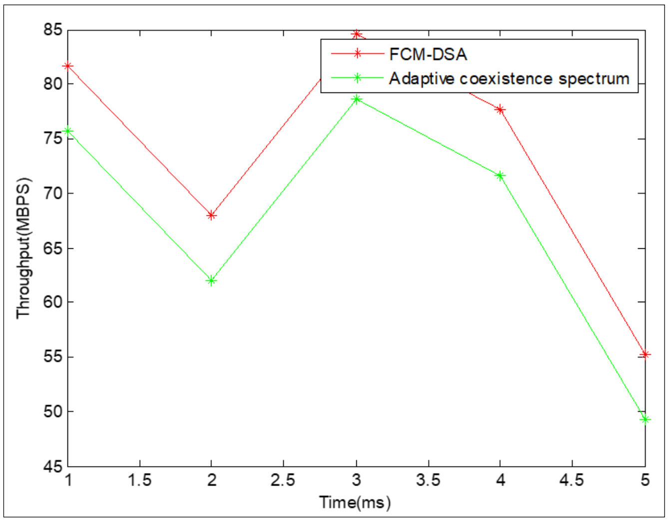

Figure 6. Representation of Throughput

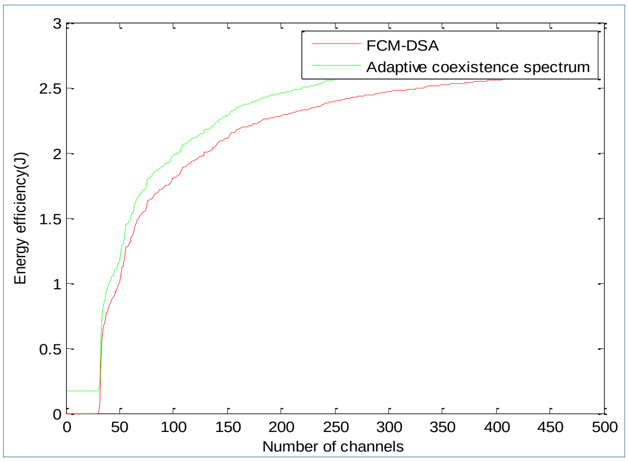

Figure 7. Comparison of Adaptive Co-Existence Spectrum and Proposed FCM-DSA

Table I Experimental Result

Time (ms)	Throughput (Mbps)	
	Adaptive Co-existence Spectrum	FCM-DSA
1	76.2	82.5
2	61.9	69.4
3	77.3	84.2
4	71.2	78.1
5	49.1	55

The throughput of the adaptive Co-existence spectrum is very minute when comparing with the proposed FCM-DSA method. It has 7% difference of throughput. Hence, from this we cannot able to justify it is better. Next parameter is energy efficiency, it is considered here to validate the result with respect to the number of channels. If the number of channels is increased then the energy efficiency is also gets increased. The comparison table I shows that simulated value with respect to the time and throughput values.

VI. CONCLUSION

In the fast growing demand of mobile broadband services, the spectrum allocation faces more issues when comparing with other concepts. Hence, this paper investigated the various concepts for allocating the spectrum with LTE domains. The dynamic spectrum allocation based on Fuzzy C-Means Clustering is considered in this research to cover the geographical area by means of non-uniform spatial traffic distribution. The overall experimental results were carried out with the MATLAB simulations and generating 25 minimum congested channels verify it. The comparison result proves that the simulation results of the proposed Fuzzy C-Means based Dynamic Spectrum Allocation throughput is improved by 6% and 2 Joules improve the energy efficiency. Hence, proposed FCM-DSA shows more efficient than the traditional Adaptive Co-existence module. In future, extent this research to incorporate the effect of correlation in the design of the user-group assignments in real time applications.

VII. REFERENCES

[1] Tabany, M. R., & Guy, C. G. (2015, July). Design and implement delay-aware QoS scheme for 3GPP LTE/LTE-A networks for mixed traffic flow. In Computers and Communication (ISCC), 2015 IEEE Symposium on (pp. 38-44). IEEE.

[2] Hu, R. Q., & Qian, Y. (2014). An energy efficient and spectrum efficient wireless heterogeneous network framework for 5G systems. IEEE Communications Magazine, 52(5), 94-101.

[3] Patel, H., Gandhi, S. D., & Vyas, D. (2016). A Research on Spectrum Allocation Using Optimal Power in Downlink Wireless system.

[4] Bao, W., & Liang, B. (2014, April). Structured spectrum allocation and user association in heterogeneous cellular networks. In INFOCOM, 2014 Proceedings IEEE (pp. 1069-1077). IEEE.

[5] Christodoulopoulos, K., Tomkos, I., & Varvarigos, E. (2013). Time-varying spectrum allocation policies and blocking analysis in flexible optical networks. IEEE Journal on Selected Areas in Communications, 31(1), 13-25.

[6] Velasco, L., Castro, A., Ruiz, M., & Junyent, G. (2014). Solving routing and spectrum allocation related optimization problems: From off-line to in-operation flexgrid network planning. Journal of Lightwave Technology, 32(16), 2780-2795.

[7] Chatterjee, B. C., Sarma, N., & Oki, E. (2015). Routing and spectrum allocation in elastic optical networks: A tutorial. IEEE Communications Surveys & Tutorials, 17(3), 1776-1800.

[8] Lee, H., Vahid, S., & Moessner, K. (2014). A survey of radio resource management for spectrum aggregation in LTE-advanced. IEEE Communications Surveys & Tutorials, 16(2), 745-760.

[9] Pai, V., Prabhu, A., & Menon, A. (2016, August). Game Theoretic optimization of spectrum allocation in cognitive radio. In Computing Communication Control and automation (ICCUBEA), 2016 International Conference on (pp. 1-5). IEEE.

[10] Huang, X. L., Zhai, Y. B., Sun, S. Y., Sun, Q. Q., & Hu, S. Q. (2016, August). Spectrum Sensing and Spectrum Allocation Algorithms in Wireless Monitoring Video Transmission. In International Conference on Machine Learning and Intelligent Communications (pp. 402-411). Springer, Cham.

[11] Akyildiz, I. F., Lee, W. Y., Vuran, M. C., & Mohanty, S. (2006). NeXt generation/dynamic spectrum access/cognitive radio wireless networks: A survey. Computer networks, 50(13), 2127-2159.

[12] Leaves, P. A. U. L., Ghaheri-Niri, S., Tafazolli, R., Christodoulides, L., Sammut, T., Staht, W., & Huschke, J. (2001). Dynamic spectrum allocation in a multi-radio environment: Concept and algorithm.

[13] Rodriguez, V., Moessner, K., & Tafazolli, R. (2006). Market driven dynamic spectrum allocation over space and time among radio-access networks: DVB-T and B3G CDMA with heterogeneous terminals. Mobile Networks and Applications, 11(6), 847-860.

[14] Kovács, L., & Vidács, A. (2006, August). Spatio-temporal spectrum management model for dynamic spectrum access networks. In Proc., First International Workshop on Technology

and Policy for Accessing Spectrum (TAPAS 2006).
[15] Hoffmann, H., Ramachandra, P., Kovács, I. Z., Jorguseski, L., Gunnarsson, F., & Kürner, T. (2015). Potential of dynamic spectrum allocation in LTE macro networks. Advances in Radio Science: ARS, 13, 95.
[16] Madan, R., Borran, J., Sampath, A., Bhushan, N., Khandekar, A., & Ji, T. (2010). Cell association and interference coordination in heterogeneous LTE-A cellular networks. IEEE Journal on Selected Areas in Communications, 28(9), 1479-1489.
[17] Xing, M., Peng, Y., Xia, T., Long, H., & Zheng, K. (2015, May). Adaptive spectrum sharing of LTE co-existing with WLAN in unlicensed frequency bands. In Vehicular Technology Conference (VTC Spring), 2015 IEEE 81st (pp. 1-5). IEEE.
[18] Bezdek, J. C., Ehrlich, R., & Full, W. (1984). FCM: The fuzzy c-means clustering algorithm. Computers & Geosciences, 10(2-3), 191-203.
[19] Dunn, J. C. (1973). A fuzzy relative of the ISODATA process and its use in detecting compact well-separated clusters.