Uluslararası Mühendislik Araştırma ve Geliştirme Dergisi
International Journal of Engineering Research and Development

UMAGD, (2020) 12(2), 693-699.

10.29137/umagd.726756

Cilt/Volume:12 Sayı/Issue:2 Haziran/June 2020

Araştırma Makalesi / Research Article

Channel Optimization By Using Spectrum Sensing Techniques In Cognitive Radio Network

Rüstem Yılmazel[*1], **Nihat İnanç**[2]

[1]*Kırıkkale Vocational High School , Kırıkkale University, 71450 Kırıkkale, TURKEY*
[3] *Department of Electrical and Electronics Eng. , Faculty of Engineering,Kırıkkale University 71450 Kırıkkale, TURKEY*

Başvuru/Received: *28/04/2020* ***Kabul / Accepted***: *10/06/2020* ***Çevrimiçi Basım / Published Online:*** *30/06/2020*
Son Versiyon/Final Version: *30/06/2020*

Abstract

In recent years, the rapid development of wireless technologies has increased the need for frequency spectrum usage. To overcome this problem, Cognitive Radio (CR) has emerged as a new technique which enables the use of free ranges in the frequency spectrum. Cognitive radio networks (CRNs) are based on the principle of benefiting from the empty spectrum of secondary users (Sus) by using sensing techniques and analyzing frequency ranges. Although the frequency spectrum is used by various technologies, some frequency ranges are used inefficiently and inadequately. Fixed spectrum allocations cause unused frequency channels in the radio frequency spectrum. Spectrum detection, which is one of the features that cognitive radio applies to reduce the inefficiency of spectrum usage, scans all the primary users (PUs) in the spectrum area and the empty frequency bands. In this study, a method has been proposed to detect unused stationary frequency bands and to use these frequency bands effectively. This method, which is named as matched filter detection , was examined in AWGN channel and its results were evaluated in MATLAB.

Key Words

"Matched filter detection, spectrum sensing, cognitive radio, neyman pearson approach"

Corresponding Author: rustemyilmazel@kku.edu.tr

1. Introduction

With the increase in the number of users in wireless communication, the gap in the frequency spectrum is insufficient for this need (Khattab 2013). According to the report published by the Federal Communications Commission (FCC) in 2002, it was found that 70% of the frequency spectrum was used efficiently. [Zahed et al. 2013] In order to use the available frequency spectra more effectively, the concept of dynamic spectrum access has been proposed. Today, CR is one of the most important structures of communication with dynamic spectrum Access (Federal Communications Commission 2002).

CR has been developed for more efficient use of frequency channels in a spectrum and is a technology that allows unlicensed (secondary) users to use these channels when licensed (primary) users in the spectrum channel do not use their frequency channels. Thus, it is aimed to increase the efficiency by allowing SUs to use appropriate channels on the frequency band. There are various spectrum detection techniques in order to enable the use of frequency channels more effectively [Tragos et al. 2013]. Thanks to these detection techniques, it is determined whether there is a licensed user in the specktrum and if it does not, the spectrum is used by unlicensed users
The concept of CR was first proposed by Josep Mitola. IEEE 802.22 standard was developed according to the proposed method (Mitola 1999). Song and Xie proposed a predefined spectrum hand-shifting approach in cognitive radio-free networks. In their proposed approach, the channel switching policy and the predefined spectrum switching protocol ensure that the spectrum switching takes place before the PU activity starts in the channel to prevent interference (Song et al. 2010).

Liu and colleagues studied spectrum shifting, the probability model of spectrum holes, and the behavior of CR users. In addition, the spectrum-shift time relationship model was proposed in their studies. In addition, the effect of spectrum shifting and the service time spent by CR users for spectrum shifting were also investigated (Liu et al. 2008). Xie and colleagues proposed a multi-cell spectrum shifting technique to solve the recurrent spectrum shifting problem, which led to poor performance of SUs.[Xie et al. 2011] Coutinho and colleagues proposed a new spectrum shifting method that reduces the probability of errors in detecting the (PU). This provides better spectrum management in order to fill the spectrum efficiently and avoid damage to the PU (Coutinho et al. 2012).

Fahimi and Ghasemi investigated how multi-spectrum shifting in CRNs affects the data transmission time of SUs. In the proposed approach, when the presence of the Pus in the licensed channel is detected, the spectrum is switched to the PU by switching the SU by initiating the shifting process. In their study, the spectrum shifting realization rate was examined and the PRP M / G / 1 queue model was used to characterize the multiple shifting process and data transmission time of the SUs. If a handover occurs while the SU is transmitting, the SU subject to the handover has a higher priority than the other SUs (Fahmi et al. 2014) .

Tianwei and colleagues proposed a comprehensive cost-based spectrum shifting algorithm. In their study, channel selection is realized by using multiple parameters such as transmission delay, channel bandwidth SNR and user characteristics. Thus, all these factors are taken into account when measuring system performance (Tianwei et al. 2014). Mahamuni and colleagues proposed a real-time empirical approach for the design of the spectrum shifting algorithm based on the spectrum detection results. Thanks to this approach, the spectrum shifting delay of the hand shift mechanism in CRNs is minimized (Mahamuni et al. 2014). Chinh Chu and colleagues developed a dynamic spectrum access technique that considers priority traffic in CRNs. PUs, first-class SUs, and second-class SUs have tehe highest priority in the technique. First class SUs have higher priority than second class SUs (Chinh et al. 2014).

2. Cognitive Radio Network

CR is a new structure that allows easy access to suitable frequency gaps. CR is defined as a system that constantly interacts with its area and can dynamically change communication parameters. The cognitive feature of CR comes from the ability of CR receivers and transmitters to perceive the surrounding radio area, analyze the information obtained and decide what needs to be done accordingly. CRN has three basic steps. these are known as spectrum detection, spectrum analysis and spectrum access decisions (Potdar et al. 2013).

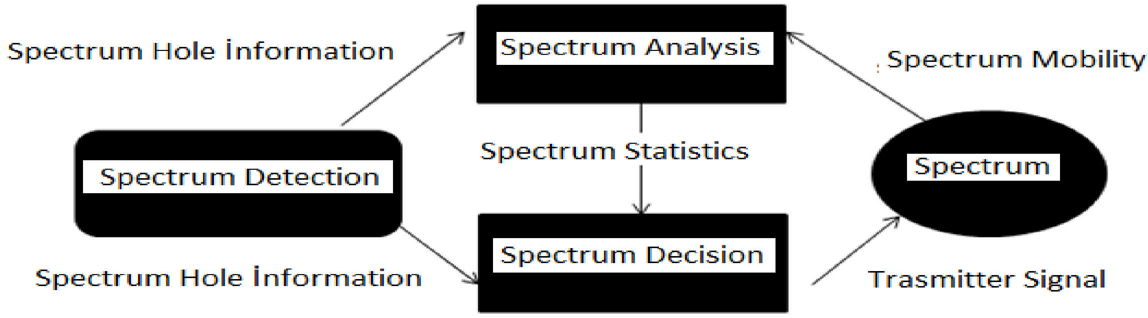

Figure 1. Cognitive Radio Area

Spectrum detection is defined as the ability of CR to measure electromagnetic interactions due to radio transmissions in different spectrum bands. Since it provides information about spectrum usage in the radio areas , the most important function of CR is seen as spectrum detection. CR should be capable of making real-time decisions about which frequency band should be detected for how long. The perceived spectrum information should be sufficient to ensure that the CR achieves accurate results. In addition, spectrum detection should be fast enough to track changes in the radio areas. The current spectrum detection techniques are based on the activities of PUs (Ahmed et al. 2013).
Spectrum analysis is the determination of the presence of spectrum gaps in the radio area according to the detected radio parameters. A spectrum hole is defined as a frequency band that is not used by Pus at a given time and location. Ttransmission activities are decided according to the results of spectrum detection and analysis in the last stage of the cycle of CR. The information in the available spectrum bands is used to define the radio receiver and transmitter parameters in order to be able to transmit in the frequency band. CR that based on perceived spectrum information and transceiver architecture determines the values of the parameters to be configured for new transmissions (Konishi et al. 2013).

3. Matched Filter Detection

Matched filter detection is the best-known method for detecting PUs if the transmitted signal is known. It is the most suitable linear filter used to obtain the maximum SNR value in the presence of additional channel noise. By matching the characteristics of the known signal with the characteristics of the unknown signal, the presence of the PU is detected. if the SU uses the spectrum, it is send to another frequency band. Otherwise, if there is no match between the two signals, the SU continues to use the frequency band (Han et al. 2010).

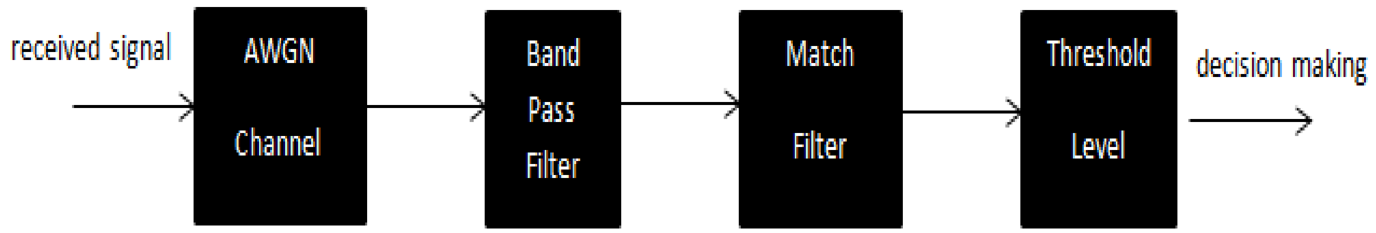

Figure 2. The block diagram of Matched filter detection

The block diagram of matched filter detection is shown in figure 2. Channel noise is added to the signal sent by the transmitter and the received signal is passed through the bandpass filter. By using the filter, signals belonging to different frequencies from the transmission channel are eliminated. The unknown signal is passed through the filter formed in accordance with the characteristics of the known signal. Finally, if the value of the received signal is above threshold level, the presence of the PU is detected and the spectrum is emptied.

4. Mathematical Equations

In this study, the results were obtained by considering the AWGN channel. If we assume that there is a gaussian noise in the transmission channel and x[n] is the received signal, The signal y[n] is as in equation .1

$$y[n] = \begin{matrix} H_0 & ;\sigma_n^2 = 0 \\ H_1 & ;\sigma_n^2 \neq 0 \end{matrix} \tag{1}$$

H0 represents that the primary user is not in the frequency band but H1 represents the presence of the primary user. The test statistic is calculated according to the status of the primary user.

$$T_{(i)} = \sum_{n=0}^{N-1} x[n]y[n] \tag{2}$$

According to the Neyman pearson approach, false alarm probability (Pfa) and detection probability (Pd) equations are calculated to evaluate the performance of the system.

$$P_{fa} = Q\left(\frac{y}{\sigma_n \sqrt{E}}\right) \tag{3}$$

$$P_d = Q\left(\frac{y - E}{\sigma_n \sqrt{E}}\right) \tag{4}$$

Q() is used to find the gaussian function.

$$E = \frac{1}{N}\sum_{n=0}^{N-1} x[n]^2 \tag{5}$$

E and γ are used to generate the threshold value for detection probability and false alarm probability. N represents the sample value. This value changes according to different SNR values.

$$N = \frac{(Q(P_{fa})^{-1} - Q(P_d)^{-1})^2}{SNR} \tag{6}$$

5. Results

In this section, we have analyzed the simulation results of the matched filter detection method through the AWGN channel. In Figure 3, matched filter detection technique and energy sensing technique were compared. As it is clear from the results obtained, match filter detection technique gave better results than energy detection technique. This is because it has more detailed information about PUs. This has led to more precise values about the threshold level. Accuracy of the threshold level has led to a reduction of the error in the detection of the PU.

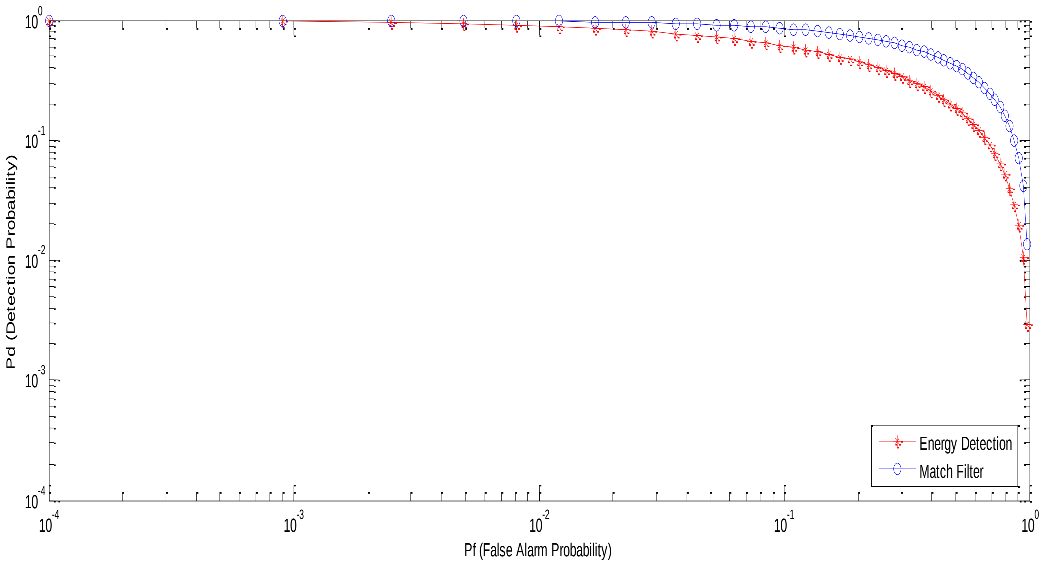

Figure 3. Comparison of matched filter detection method and energy sensing technique

In Figure 4-5, We analyzed the performance of matched filter detection technique according to different SNR values. As the SNR value increases, there should be a decrease in system performance. Because the amount of noise in the radio area will increase, the possibility of making a wrong decision in the system will increase. The ideal SNR value is considered to be 1-2 dB. When we look at our results, performance is quite good about 2 dB. There was a slight decrease in performance as the SNR increased in the system, which is quite normal.

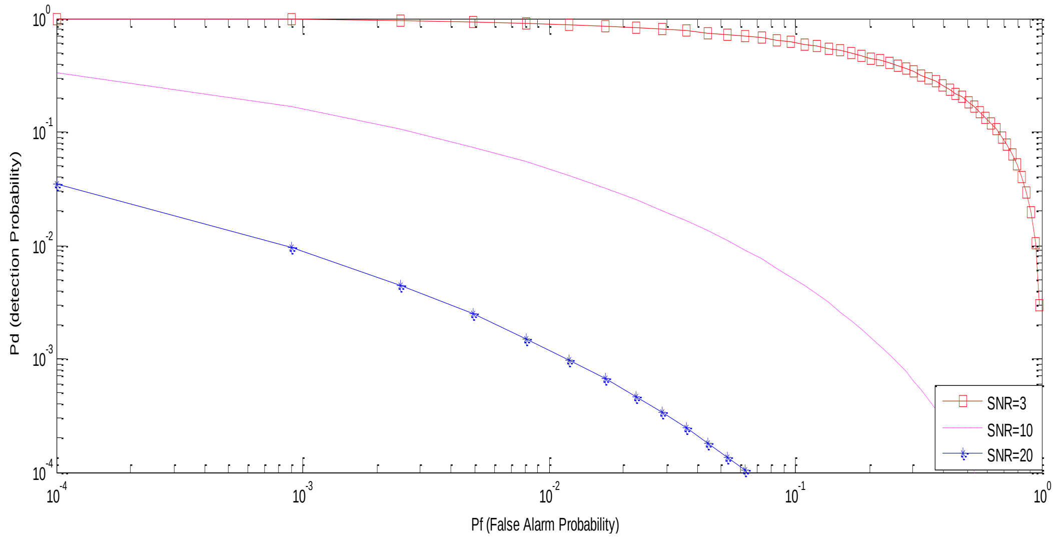

Figure 4. Comparing the results for different SNR values

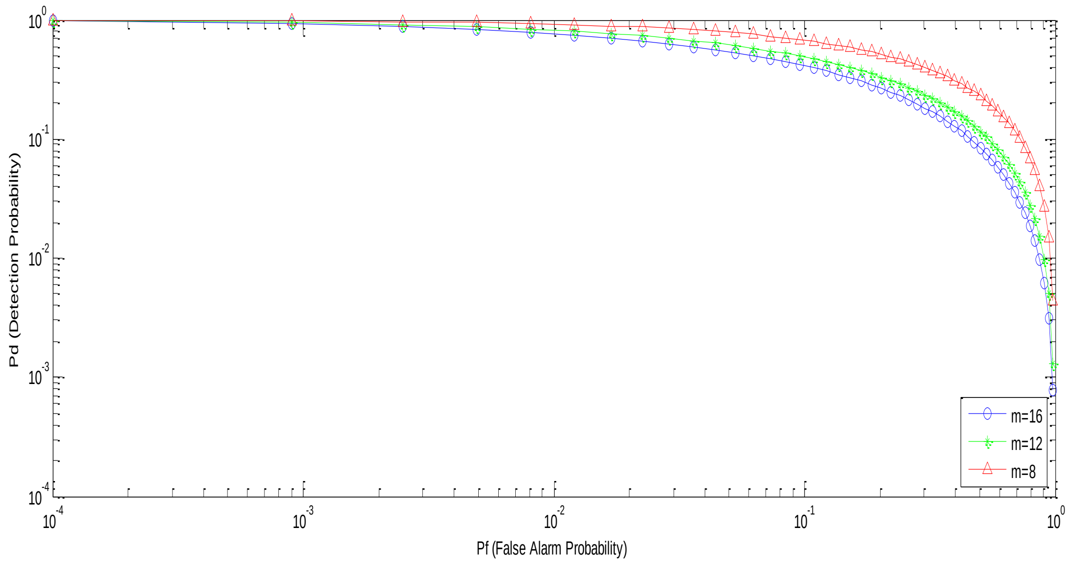

Figure 5. Comparing the results for different sample times

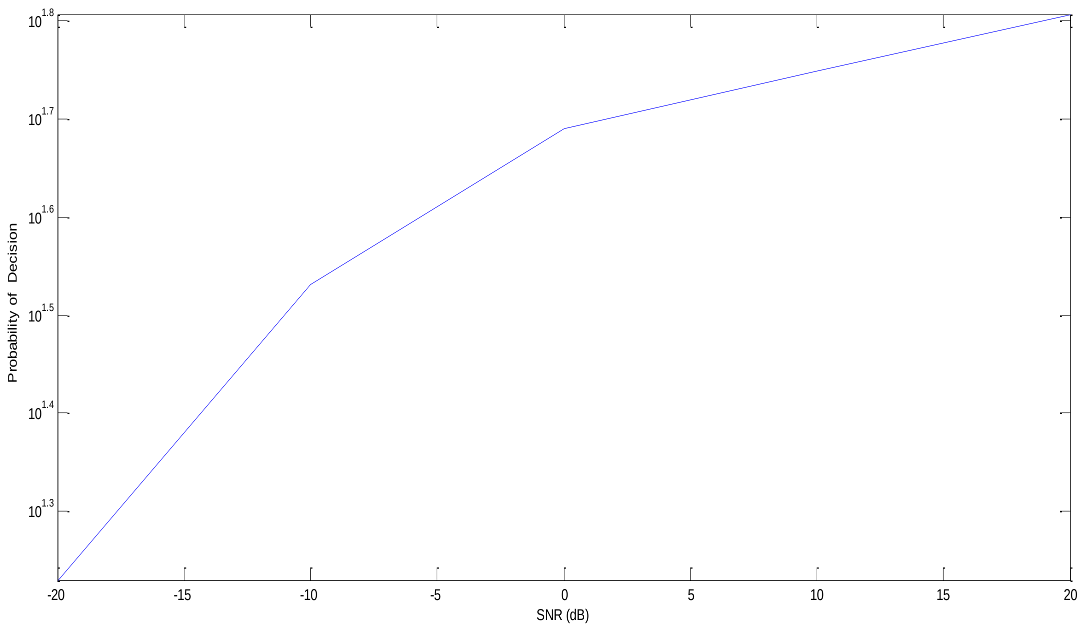

Figure 6. Comparing the results for SNR values and probability of detection

It is shown that how the detection probability of the system changes according to all SNR values in Figure-6. According to the results , the probability of decision increases as the signal power increases. It can be seen from the results that the system is not affected by the noise effects. It shows the effects of the method used on detection probability. As the SNR value increases, the probability of decision is almost error free.

6. Conclusion

In order to accurately detect gaps in the frequency spectrum, matched filter detection method has been applied in this article To detect the primary user on AWGN channel, the results are examined by using matched filter detection technique. According to the results, it was found that the signal detection using matched filter detection technique gives good results even at very low SNR values. It was observed that the results obtained increased as the SNR values increased. According to the Neyman pearson approach, the probability of detection increases as the probability of false alarm detection decreases. When the false alarm probability increases too much, the threshold value will decrease and it will be difficult to detect the primary user. In this case, the probability of detection will also decrease. It has been observed that the primary user can be detected at very low times and increase the system gain.

References

Ahmed, E., Yao, L. J., Shiraz, M., Gani, A. and Ali S. (2013) 'Fuzzy based Spectrum Handoff and Channel Selection for Cognitive Radio Networks', Conference Proceedings, IEEE International Conference on Computer, Control, Informatics

Bragança, H., Diogo, E., Moniz, F., Amaro, P. (2009). First report of pitch canker on pines caused by Fusarium circinatum in Portugal. Plant Disease, 93(10), 1079-1079.

Chinh Chu, T.M., Phan, H., Zepernick, H.J., "Dynamic Spectrum Access for Cognitive Radio Networks with Prioritized Traffics", IEEE Communications Letters, 18, 1218-1221, 2014.

Coutinho, P.S., Rocha Da Silva, M.W., De Rezende, J.F., "Detection Error Aware Spectrum Handoff Mechanism for Cognitive Radios", International ICST Conference on Cognitive Radio Oriented Wireless Networks and Communications, 48-53. Stockholm, Sweden, 2012.

Fahmi, M., Ghasemi, A., "Analysis of the PRP M/G/1 Queuing System for Cognitive Radio Networks with Handoff Management", Iranian Conference on Electrical Engineering, 1047-1051. Tehran, Iran, 2014.

Federal Communications Commission (FCC), "Spectrum policy task force," ET Docket No. 02-135, November 2002.

Han, H., Wu, Q. and Yin, H. (2010) 'Spectrum Sensing for Real Time Spectrum Handoff in CRNs', Conference Proceedings, IEEE International Conference on Advanced Computer Theory and Engineering, Chengdu, pp. V1-480 – V1-484.

Kamra, S.K. (1989). Improving the forest seed situation in some African countries. Turnbull, J. W. (Ed.) Tropical Tree Seed Research. Gympie, Australia.

Khattab A. (2013) Cognitive Radio Networks: From Theory to Practice, New York: Springer Science & Business Media.

Konishi, Y., Masuyama, H., Kasahara, S. and Takahashi, Y. (2013) 'Performance Analysis of Dynamic Spectrum Handoff Scheme with Variable Bandwidth Demand of Secondary Users for Cognitive Radio Networks', Wireless Networks Journal, vol. 19, no. 5, July, pp. 607- 617.

Liu, H.J., Wang, Z.X., Li, S.F., Yi, M., "Study on the Performance of Spectrum Mobility in Cognitive Wireless Network", IEEE Singapore International Conference on Communication Systems, 1010-1014. Guangzhou, China, 2008.

Mahamuni, S.M., Mishra, V., Fernandes, R., "Detection of Spectrum in Cognitive Radio Network for Efficient Spectrum Handoff Mechanism", International Conference on Emerging Technology Trends in Electronics, Communication and Networking, 1-6. Surat, India, 2014.

Mitola J., Maguire G.O., "Cognitive radios: making software radios more personal," IEEE Personal Commu-nications, 1999, vol. 6, p.13-18.

Pinestrength, (2017). COST Action FP1406: Pine pitch canker strategies for management of Gibberella circinata in greenhouses and forests (Pinestrength). http://www.pinestrength.eu/ (Erişim Tarihi: 05.04.2017).

Potdar, S. M. and Patil, K. P. (2013) ‘Efficient Spectrum Handoff in CR Network based on Mobility, QoS and Priority using Fuzzy Logic and Neural Networks’, Conference Proceedings, IEEE International Conference on Contemporary Computing, Noida, pp. 53 – 58.

Song, Y., Xie, J., “Common Hopping based Proactive Spectrum Handoff in Cognitive Radio Ad Hoc Networks”, IEEE Global Telecommunications Conference, 1-5. Miami, USA, 2010.

Tianwei, W., Yafeng, W., Chao, L., “A Spectrum Handoff Scheme based on Comprehensive Cost in Cognitive Radio System”, International Conference on Wireless Communications, Vehicular Technology, Information Theory and Aerospace & Electronic Systems, 1-5. Aalborg, Denmark, 2014.

Tragos, E. Z., Zeadally, S., Fragkiadakis and A. G. and Siris, V. A. (2013) ‘Spectrum Assignment in Cognitive Radio Networks: A Comprehensive Survey’, IEEE Communications Surveys & Tutorials, vol. 15, no. 3, July, pp. 1108-1135.

TÜİK, (2015). Türkiye İstatistik Kurumu. http://www.tuik.gov.tr/Start.do (Erişim Tarihi: 12.04.2017).

Xie, X., Yang, G., Ma, B., “Spectrum Handoff Decision Algorithm with Dynamic Weights in Cognitive Radio Networks”, Global Mobile Congress, 1-6. Shanghai, China, 2011.

Zahed, S., Awan, I. and Cullen, A. (2013) ‘Analytical Modeling for Spectrum Handoff Decision in Cognitive Radio Networks’, Simulation Modelling Practice And Theory Journal, vol. 38, November, pp. 98-114.