IJCSE International Journal of Computer Sciences and Engineering Open Access
Review Paper | Volume-3, Issue-9 | E-ISSN: 2347-2693

Band Identifying Methods as well as Problems in CR Network

D.Vinoth[1*] and A.Immaculate Mercy[2]

[1*,2] *PG and Research Department of Computer Science, Maruthupandiyar College, Thanjavur.*

www.ijcseonline.org

Received: Aug/22/2015 Revised: Aug/30/2015 Accepted: Sep/24/2015 Published: Sep/30/2015

***Abstract*—** In present day communication wireless communication has become the most popular communication. Because of this growing demand on wireless applications has put a lot of constraints on the available radio band which is limited and precious. In fixed band assignments there are many frequencies that are not being properly used. So cognitive radio helps us to use these unused frequency bands which are also called as "White Spaces". This is a unique approach to improve utilization of radio electromagnetic band. In establishing the cognitive radio there are 4 important methods. In this paper we are going to discuss about the first and most important method to implement cognitive radio i.e., "band sensing". The challenges, issues and techniques that are involved in band sensing will discussed in detail.

***Keywords*—** Primary User, Secondary User, Band Sensing, Signal Processing Techniques

I. INTRODUCTION

As the need of wireless communication applications are increasing the available Electromagnetic Band band is getting crowded day by day. According to many researches it has been found that the allocated band (licensed band) is not utilized properly because of static allocation of band. It has become most difficult to find vacant bands either to set up a new service or to enhance the existing one. In order to overcome these problems we are going for "Dynamic Band Management" which improves the utilization of band

Cognitive Radio works on this dynamic Band Management principle which solves the issue of band underutilization in wireless communication in a better way. This radio provides a highly reliable communication. In this the unlicensed systems (Secondary users) are allowed to use the unused band of the licensed users (Primary users). Cognitive radio will change its transmission parameters like wave form, protocol, operating frequency, networking etc based on the interaction with environment in which it operates [2]. Figure 1 shows the Dynamic Band Access in Cognitive Radio.

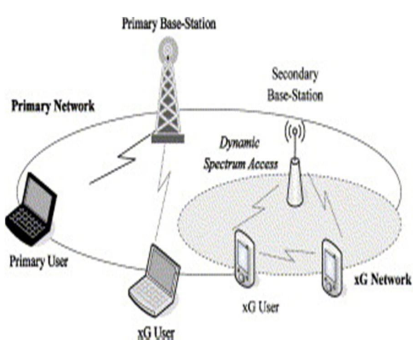

Fig. 1: Dynamic Band Access

Cognitive radio has four major functions. They are Band Sensing, Band management, Band Sharing and Band Mobility. Band Sensing is to identify the presence of licensed users and unused frequency bands i.e., white spaces in those licensed bands. Band Management is to identify how long the secondary users can use those white spaces. Band Sharing is to share the white spaces (band hole) fairly among the secondary users. Band Mobility is to maintain unbroken communication during the transition to better band.

In terms of occupancy, sub bands of the radio spectrum may be categorized as follows:

A. *White spaces:* These are free of RF interferers, except for noise due to natural and/or artificial sources.
B. *Gray spaces:* These are partially occupied by interferers as 2) Cooperative and collaborative detection: The primary well as noise. Signals for band opportunities are detected reliably by interacting or cooperating with other users, and the method
C. *Black spaces:* The contents of which are completely full can be implemented as either centralized access to band due to the combined presence of communication and coordinated by a band server or distributed approach (possibly) interfering signals plus noise.

Figure 2 shows the White Spaces and Used Frequencies in Licensed Band

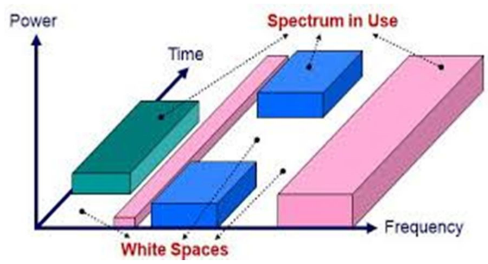

Fig. 2: Illustration of White Spaces in Licensed Bands

When compared to all other techniques, Band Sensing is the most crucial task for the establishment of cognitive radio based communication mechanism.

II. BAND SENSING

The major challenge of the cognitive radio is that the secondary user needs to detect the presence of primary user and to quickly quit the frequency band if the corresponding primary radio emerges in order to avoid interference to primary users.

Band sensing technique can be categorized into two types. They are: Direct and Indirect Techniques. Direct Technique is also called as frequency domain out in which estimation is carried out directly from signal approach. Where as in Indirect Technique (also called as time domain approach), in this technique estimation is performed using autocorrelation of the signal. Another way of classification depends on the need of band sensing as stated below.

A. Band Sensing for Band opportunities

1) Primary transmitter detection: Based on the received signal at CR users the detection of primary users is performed. This approach includes matched filter (MF) based detection, energy based detection, covariance based detection, waveform based detection, cyclostationary based detection, Primary Transmitter Detection etc.,

Implied by the band load smoothing algorithm or external detection.

B. Band Sensing for Interference Detection

1) Interference temperature detection: In this approach, CR system works as in the ultra-wide band (UWB) technology where the secondary users coexist with primary users and are allowed to transmit with low power and are restricted by the interference temperature level so as not to cause harmful interference to primary users.

2) Primary receiver detection: In this method, the interference and/or band opportunities are detected based on primary receiver's local oscillator leakage power.

III. CLASSIFICATION OF BAND SENSING TECHNIQUES

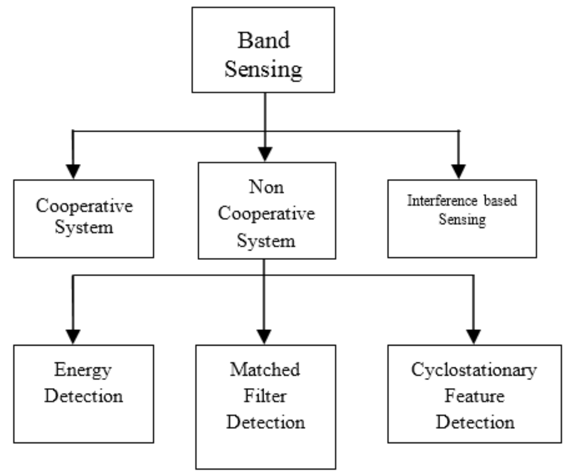

Fig.3 Band Sensing Techniques

A. Primary Transmitter Detection: In this we are going to discuss about few primary transmitter detection techniques. They are:

1) Energy Detection: In this technique there is no need of prior knowledge of Primary signal energy.

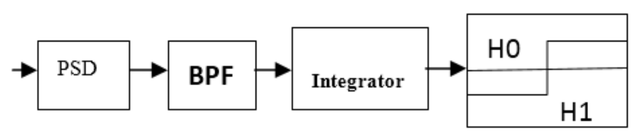

Fig. 4: Block Diagram of Energy Detection

Where H0 = Absence of User.
H1 = Presence of User.

The block diagram for the energy detection technique is shown in the Figure 4. In this method, signal is passed through band pass filter of the bandwidth W and is integrated over time interval. The output from the integrator block is then compared to a predefined threshold. This comparison is used to discover the existence of absence of the primary user. The threshold value can set to be fixed or variable based on the channel conditions.

$$y(k) = n(k) \ldots\ldots\ldots\ldots\ldots H0$$
$$y(k) = h * s(k) + n(k) \ldots\ldots H1$$

Where y (k) is the sample to be analyzed at each instant k and n (k) is the noise of variance σ2. Let y(k) be a sequence of received samples kϵ{1, 2….N} at the signal detector, then a decision rule can be stated as,

H0…… if ε > v
H1…… if ε < v

Where ε = E ly(k)l2 the estimated energy of the received signal and v is chosen to be the noise variance σ2.

However ED is always accompanied by a number of disadvantages i) Sensing time taken to achieve a given probability of detection may be high. ii) Detection performance is subject to the uncertainty of noise power. iii) ED cannot be used to detect spread band signals.

B. Matched Filter

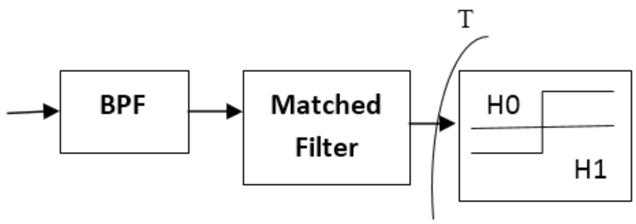

Fig.5 Block Diagram of Matched Filter

Where H0 = Absence of User.
H1 = Presence of User.

A matched filter (MF) is a linear filter designed to maximize the output signal to noise ratio for a given input signal. When secondary user has a priori knowledge of primary user signal, matched filter detection is applied. Matched filter operation is equivalent to correlation in which the unknown signal is convolved with the filter whose impulse response is the mirror and time shifted version of a reference signal. The operation of matched filter detection is expressed as:

$$Y[n] = \Sigma\, h[n-k]\, x[k]$$

Where 'x' is the unknown signal (vector) and is convolved with the 'h', the impulse response of matched filter that is matched to the reference signal for maximizing the SNR. Detection by using matched filter is useful only in cases where the information from the primary users is known to the cognitive users.

Advantages: Matched filter detection needs less detection time because it requires only O (1/SNR) samples to meet a given probability of detection constraint. When the information of the primary user signal is known to the cognitive radio user, matched filter detection is optimal detection in stationary Gaussian noise.

Disadvantages: Matched filter detection requires a prior knowledge of every primary signal. If the information is not accurate, MF performs poorly. Also the most significant disadvantage of MF is that a CR would need a dedicated receiver for every type of primary user.

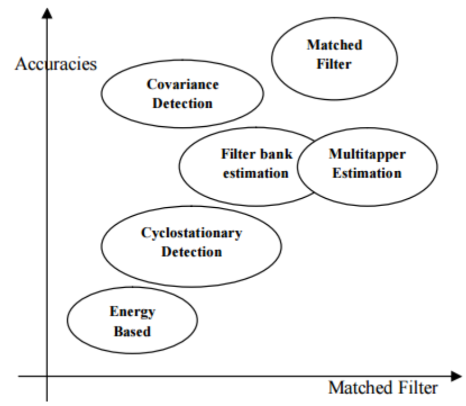

Fig.6 Sensing accuracy and complexity of various sensing methods

B. Cooperative Techniques

1) Decentralized Uncoordinated Techniques: In uncoordinated techniques Cognitive Radio will independently detects the channel and will vacate the channel when it finds a primary user without informing the other users. So Cognitive Radio users will experience bad channel realizations detect the channel incorrectly thereby causing interference at the primary receiver. So these are not advantageous when compared to coordinated techniques.

2) Centralized Coordinated Techniques: Here in this technique we have Cognitive Radio controller. When one Cognitive Radio detects the presence of primary user then it intimates the Cognitive Radio controller about it. Then that controller informs all the Cognitive radio users by broadcast method. This is further more classified into two types as partially cooperative in which network nodes cooperate only in sensing the channel. The other technique is totally cooperative in which nodes cooperate in relaying each other's information in addition to cooperatively sensing the channel.

3) Decentralized Coordinated Techniques: This type of coordination implies building up a network of cognitive radios without having the need of a controller. Various algorithms have been proposed for the decentralized techniques among which are the gossiping algorithms or clustering schemes, where cognitive users gather to clusters, auto coordinating themselves. The cooperative band sensing raises the need for a control channel, which can be implemented as a dedicated frequency channel or as an underlay UWB channel.

4) Advantages of Cooperation: Cognitive users selflessly cooperating to sense the channel have lot of benefits among which the plummeting sensitivity requirements: channel impairments like multipath fading, shadowing and building penetration losses, impose high sensitivity requirements inherently limited by cost and power requirements.

5) Disadvantages: Cooperative technique even has disadvantage like the CR users need to perform sensing at periodic time intervals as sensed information become fast due to factors like mobility, channel impairments etc.

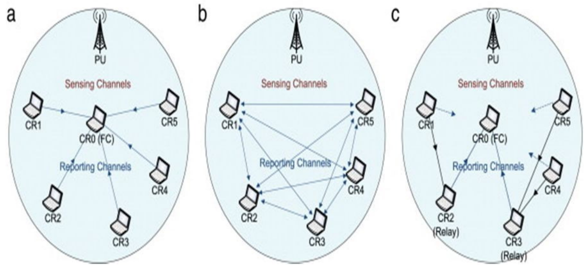

Fig. 7: a-Centralized Coordinated, b-Decentralized Coordinated, and c-Decentralized Uncoordinated

B. Interference Based Detection: In this section, we present interference based detection so that the CR users would operate in band underlay (UWB like) approach.

1) Primary Receiver Detection: Primary receiver emits the local oscillator (LO) leakage power from its RF front end while receiving the data from primary transmitter. It has been suggested as a method to detect primary user by mounting a low cost sensor node close to a primary user's receiver in order to detect the local oscillator (LO) leakage power emitted by the RF front end of the primary user's receiver which are within the communication range of CR system users. The local sensor then reports the sensed information to the CR users so that they can identify the band occupancy status. We note that this method can also be used to identify the band opportunities to operate CR users in band overlay.

2) Interference Temperature Management: Unlike the primary receiver detection, the basic idea behind the interference temperature management is to set up an upper interference limit for given frequency band in specific geographic location such that the CR users are not allowed to cause harmful interference while using the specific band in specific area. Typically, CR user transmitters control their interference by regulating their transmission power (their out of band emissions) based on their locations with respect to primary users. This method basically concentrates on measuring interference at the receiver. The operating principle of this method is like an UWB technology where the CR users are allowed to coexist and transmit simultaneously with primary users using low transmit power that is restricted by the interference temperature level so as not to cause harmful interference to primary users.

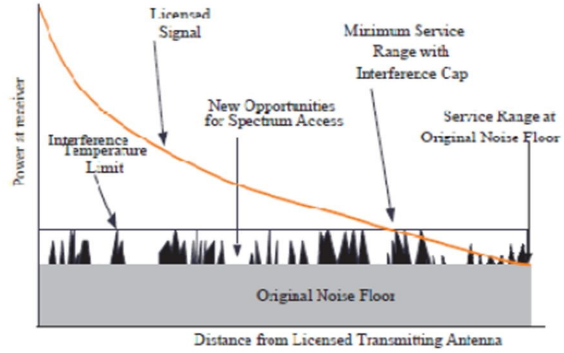

Fig. 8: Inference Temperature Model

IV. ISSUES IN BAND SENSING

A. Channel Uncertainty: Because of fading or shading of the channel there will be uncertainties in the received signal strength which will lead to wrong interpretation. To avoid this Cognitive Radios must have high sensitivity so that he can differentiate between faded primary signal and a white space. If the fading is severe, a single cognitive radio cannot give high sensitivity so handle this we go for a set of cognitive radios which share their local measurements and collectively decide on the occupancy state of a licensed band.

B. Noise Uncertainty: The detection sensitivity can be defined as the minimum SNR at which the primary signal can be accurately detected by the cognitive radio and is given by

$$\gamma_{min} = \frac{P_p L(D+R)}{N}$$

Where N= Noise power.

Pp= Power Transmitted by Primary User.

D = Interference Range of Secondary User.

R = Maximum distance between Primary Transmitter and corresponding Receiver.

The noise power estimation is limited by calibration errors as well as changes in thermal noise caused by temperature variations. Since a cognitive radio may not satisfy the sensitivity requirement due to underestimate of N, γ_{min} should be calculated with the worst case noise assumption, thereby necessitating more sensitive detector.

C. Aggregate Interference Uncertainty: If multiple Cognitive Radios are operating same in same licensed band which will lead to band sensing will be affected by uncertainty in aggregate interference. Even though the primary user is out of interference range this uncertainty may lead to wrong detection so this uncertainty will create a need of more sensitive detector.

D. Sensing Interference Limit: There are two factors for this issue that is when an unlicensed user may not know exactly the location of the licensed receiver which is required to compute interference caused due to its transmission and the second reason is that if a licensed receiver is a passive device, the transmitter may not be aware of the receiver. So these factors need attention while calculating the sensing interference limit.

V. CONCLUSION

As the usage of frequency band is increasing, it is becoming more valuable. So we need to access the frequency band wisely. For this purpose we are using Cognitive Radio. In our paper we discussed about the most important technique that is Band sensing and the issues involved in it to establish the communication using Cognitive radio. We also said about important the importance of cooperation between Secondary users to avoid interference.

REFERENCES

[1] Yao Liu ; Dept. of Comput. Sci., North Carolina State Univ., Raleigh, NC, USA ; Peng Ning ; Huaiyu Dai, "Authenticating Primary Users' Signals in Cognitive Radio Networks via Integrated Cryptographic and Wireless Link Signatures", Published in: Security and Privacy (SP), 2010 IEEE Symposium on Date of Conference: 16-19 May 2010 Page(s): 286 – 301.

[2] Canberk, B. ; Broadband Wireless Networking Lab. (BWNLab), Georgia Inst. of Technol., Atlanta, GA, USA ; Akyildiz, I.F. ; Oktug, S., "Primary User Activity Modeling Using First-Difference Filter Clustering and Correlation in Cognitive Radio Networks", Published in: Networking, IEEE/ACM Transactions on (Volume:19 , Issue: 1) Page(s): 170 – 183 ISSN : 1063-6692.

[3] Rahimian, N.; Dept. of Electr. & Comput. Eng., Texas A&M Univ., College Station, TX, USA ; Georghiades, C.N. ; Shakir, M.Z. ; Qaraqe, K.A., "On the Probabilistic Model for Primary and Secondary User Activity for OFDMA-Based Cognitive Radio Systems: Spectrum Occupancy and System Throughput Perspectives", Published in: Wireless Communications, IEEE Transactions on (Volume:13 , Issue: 1) Page(s): 356 – 369 ISSN : 1536-1276.

[4] Chang, K. ; Sch. of Eng. Syst., Queensland Univ. of Technol., Brisbane, QLD, Australia ; Senadji, B., "Spectrum Sensing Optimisation for Dynamic Primary User Signal", Published in: Communications, IEEE Transactions on (Volume:60 , Issue: 12) Page(s): 3632 – 3640 ISSN : 0090-6778.

[5] Saifan, R. ; Dept. of Electr. & Comput. Eng., Iowa State Univ., Ames, IA, USA ; Yawen Wei ; Guan, Yong, "A Framework for Cooperative In-Band Sensing in Cognitive Radio Network", Published in: Networking Technologies for Software Defined Radio (SDR) Networks, 2010 Fifth IEEE Workshop on Date of Conference: 21-21 June 2010 Page(s): 1 – 6.

[6] Hyoil Kim ; Dept. of Electr. Eng. & Comput. Sci., Univ. of Michigan, Ann Arbor, MI, USA ; Shin, K.G., "In-Band Spectrum Sensing in IEEE 802.22 WRANs for Incumbent Protection", Published in: Mobile Computing, IEEE Transactions on (Volume:9 , Issue: 12) Page(s): 1766 – 1779.

[7] Rong Cong ; Coll. of Commun. & Inf. Eng., Nanjing Univ. of Posts & Telecommun., Nanjing, China ; Zhen Yang, "Optimization of out-band sensing time in cognitive radios", Published in: Progress in Informatics and Computing (PIC), 2010 IEEE International Conference on (Volume:1) Date of Conference: 10-12 Dec. 2010 Page(s): 383 – 387.

[8] Jembre, Y.Z. ; Sch. of Inf. & Comput. Eng., Ajou Univ., Suwon, South Korea ; Young-June Choi ; Wooguil Pak, "Out-of-Band Sensing for Seamless Communication in Cognitive Radio Systems", Published in: Ubiquitous Information Technologies and Applications (CUTE), 2010 Proceedings of the 5th International Conference on Date of Conference: 16-18 Dec. 2010 Page(s): 1 – 4.

[9] Liu, W. ; Dept. of Inf. Technol., Ghent Univ., Ghent, Belgium ; Yaron, O. ; Moerman, I. ; Bouckaert, S., "Real-time wide-band spectrum sensing for cognitive radio", Published in: Communications and Vehicular Technology in the Benelux (SCVT), 2011 18th IEEE Symposium on Date of Conference: 22-23 Nov. 2011 Page(s): 1 – 6.

[10] Bogale, T.E. ; Inst. Nat. de la Rech. Sci. (INRS), Univ. du Quebec, Montreal, QC, Canada ; Vandendorpe, L. ; Long Bao Le, "Wide-Band Sensing and Optimization for Cognitive Radio Networks With Noise Variance Uncertainty", Published in: Communications, IEEE Transactions on (Volume:63 , Issue: 4) Page(s): 1091 – 1105.

[11] Blaschke, V. ; Inst. fur Nachrichtentechnik, Univ. Karlsruhe, Karlsruhe ; Renk, T. ; Jondral, F.K., "A Cognitive Radio Receiver Supporting Wide-Band Sensing", Published in: Communications Workshops, 2008. ICC Workshops '08. IEEE International Conference on Date of Conference: 19-23 May 2008 Page(s): 499 – 503.

[12] Dautrich, B.A. ; Rabiner, L.R. ; Martin, T.B., "The effects of selected signal processing techniques on the performance of a filter-bank-based isolated word recognizer", Published in: Bell System Technical Journal, The (Volume:62 , Issue: 5) Page(s): 1311 – 1336.

[13] Kia, S.H. ; Dept. of Electr. Eng., Univ. of Picardie Jules Verne, Amiens, France ; Henao, H. ; Capolino, G., "Efficient digital signal processing techniques for induction machines fault diagnosis", Published in: Electrical Machines Design Control and Diagnosis (WEMDCD), 2013 IEEE Workshop on Date of Conference: 11-12 March 2013 Page(s): 232 – 246.

