Channel Aware Spectrum Sensing and Increase Energy Efficiency in Cognitive Radio Networks

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Abstract- *The cognitive radio network has less efficiency by two main functions namely spectrum sensing and spectrum sharing. This paper proposed new spectrum sensing and sharing techniques energy detection method. The fifth generation (5G) wireless networks are expected to achieve 1000 times higher capacity compared to the fourth generation (4G) wireless networks. Thus, improving the energy efficiency is a crucial problem, which must be considered. Cognitive radio (CR) is considered as an effective approach to alleviate the energy scarcity problem. The goal of the project is to enhance the energy efficiency of data transmission and reduces the noise in wireless networks. In order to improve the energy efficiency, we formulate a new multi objective optimization problem minimizes the average transmission power of the secondary user network while limiting the average interference power imposed on the primary user receiver. In Cognitive Radio network the users are classified into Licensed Primary Users and Unlicensed Secondary Users and there is no dedicated channel to send data, sensors need to negotiate with the neighbours and select a channel for data communication in CR-WSNs. this is a very challenging issue, because there is no cooperation between the PUs and SUs. PUs may arrive on the channel any time. If the PU claims the channel, the SUs have to leave the channel immediately. PU is communicating with another user, that time SU cannot communicate to PU at particular time. Our proposed cognitive radio method helps to automatically search the users those who are free to communicate in the network, at that time Unlicensed user is automatically will change as licensed user, then it communicate to particular person. The technique used to increase the energy efficiency is ad hoc distribution algorithm and no need of any centralized server for communication.*

Keywords- cognitive radio network, spectrum sharing, spectrum sensing.

I. INTRODUCTION

In Today's wireless systems, there is an increased demand for the radio spectrum access due to many new wireless networks such as wireless sensor networks, wireless local area networks, Bluetooth, and so on. The frequency allocation chart of the Federal Communications Commission (FCC) shows that a severe under-utilization of the licensed spectrum has been observed. Cognitive radio networks have been proposed as an efficient method to address the problem by opportunistically accessing the spectrum across different networks of users. A cognitive radio network consists of primary users (PU) and secondary users (SU). As described in [5], a PU has the legacy priority access to the spectrum while an SU uses the spectrum when the performance of the Pus is not harmfully affected by the SU network operation. The utilization of the spectrum in traditional wireless networks is improved by cognitive radio technology such that it increases the number of application and services in wireless systems. A Cognitive radio network recognizes its communication environment and changes the parameters of its communication scheme to increase the quality of service (QoS) of SUs[6]. Cognitive radio technologies can be divided into two main modes, namely; spectrum sensing and spectrum sharing. In the latter, the SU is required to detect the spectrum opportunities and then transmit while the PU is absent [7].With the rapid development of wireless communications, frequency spectrum is becoming a very precious resource and scarcity of the spectrum is a serious problem. In some cases, the spectrum bands are not efficiently utilized because licensed users do not always occupy their spectrum and unlicensed users are not allowed to operate in such spectrum bands. This governance leads to unbalanced spectrum utilization.

Cognitive radio is an intelligent wireless communication system that is aware of its surrounding environment (i.e., outside world), and uses the methodology of understanding-by-building to learn from the environment and adapt its internal states to statistical variations in the incoming RF stimuli by making corresponding changes in certain operating parameters (e.g., transmit-power, carrier-frequency, and modulation strategy) in real-time, with two primary objectives in mind:

- Highly reliable communications whenever and wherever needed.
- Efficient utilization of the radio spectrum.

The two important characteristics of cognitive radio are:-

a) Cognitive capability- Cognitive capability refers to the ability of the cognitive radio technology to capture or sense the information from its radio environment.

b) Reconfigurability – Reconfigurability enables the cognitive radio to be programmed dynamically according to the radio environment.

II. SYSTEM DESIGN

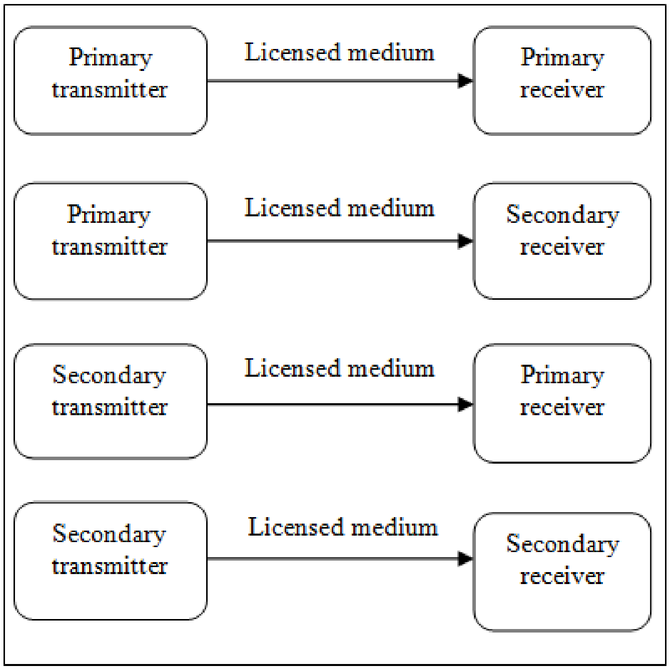

Fig.1 cognitive radio four modes of communication

A.SYSTEM DESCRIPTION

1. Primary System and Cognitive Radio System

There are two kinds of wireless communication systems in CRNs: Primary System and Cognitive Radio System, which are classified by their priorities on frequency bands. A primary system is referred to an existing system which operates in one or many fixed frequency bands. Various kinds of primary systems work either in licensed or unlicensed bands and are explained as follows.

2. Primary System in Licensed Bands

A primary system operated in the licensed band has the highest priority to use that frequency band (e.g. 2G/3G cellular, digital TV broadcast). Other unlicensed users/systems can neither interfere with the primary system in an intolerable way nor occupy the license band.

3. Primary System in Unlicensed Bands

A primary system operating in the unlicensed band (e.g. ISM band) called unlicensed band primary system. Various primary systems should use the band compatibly. Specifically, primary systems operating in the same unlicensed band shall coexist with each other while considering that the interference to each other. These primary systems may have different levels of priorities which may depend on some regulations.

A cognitive radio system neither has a fixed operating frequency band nor has privilege to access that band. Entities of this system communicate with each other by dynamically using spectrum holes. There are two components in CR systems: Cognitive Radio Base Station (CR-BS) and Cognitive Radio Mobile Station (CRMS).

III. SPECTRUM SENSING

ENERGY DETECTION METHOD

Energy detection is the most popular spectrum sensing method since it is simple to implement and does not require any prior information about the primary signal. An energy detector (ED) simply treats the primary signal as noise and decides on the presence or absence of the primary signal based on the energy of the observed signal.

Since it does not need any a priori knowledge of the primary signal, the ED is robust to the variation of the primary signal. Moreover, the ED does not involve complicated signal processing and has low complexity. In practice, energy detection is especially suitable for wide-band spectrum sensing. Energy detector is composed of four main blocks.

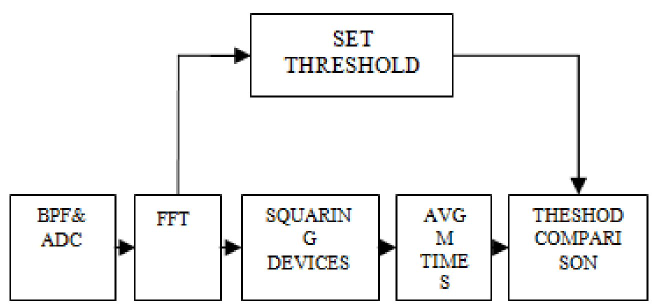

Fig 2.energy detection based spectrum sensing

$$Y` = \frac{1}{N_0} \int_0^T y^2\,(t) d$$

The decision metric for the energy detector can be written as:-

$x(t)$={ $n(t)$ ho

{$h(t)$+ $n(t)$ $h1$

IV. SPECTRUM SHARING

Spectrum management assigns the available spectrum holes among the cognitive radios and is one of the main challenges in cognitive radio. In cognitive radio networks, the unused spectrum bands will be spread over wide frequency range. These unused spectrum bands detected through spectrum sensing show different characteristics according to the time varying radio environment and the spectrum band information such as the operating frequency and bandwidth. So, now the cognitive radio networks should select the available unused spectrum bands and assign them to the secondary users. The selection of unused spectrum bands by cognitive radio network is known as spectrum management. In cognitive radio networks, one of the main challenges in open spectrum usage is the spectrum sharing. Once the unused spectrum band is selected by cognitive radio network, it is assigned to the secondary user, this process is known as spectrum sharing**.**

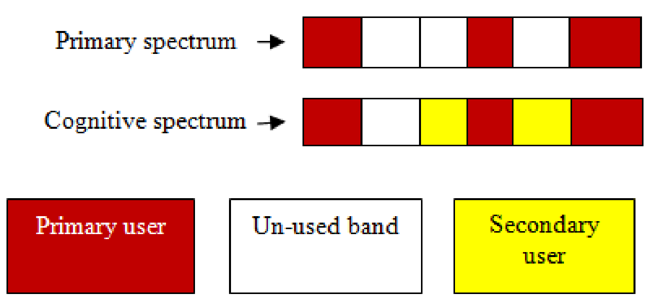

Fig3. Spectrum sharing with secondary user

AWGN CHANNEL

Additive white Gaussian noise (AWGN) is a basic noise model used in Information theory to mimic the effect of many random processes that occur in nature. The modifiers denote specific characteristics:

Additive because it is added to any noise that might be fundamental to the information system.

White refers to the idea that it has uniform power across the frequency band for the information system. It is an analogy to the color white which has uniform emissions at all frequencies in the visible spectrum.

Gaussian because it has a normal distribution in the time domain with an average time domain value of zero.

CLASSIFICATION OF Ad Hoc NETWORK:

Wireless ad hoc networks can be further classified by their application:

Wireless Mesh Network (WMN)

Wireless mesh networks often consist of mesh clients, mesh routers and gateways. The mesh clients are often laptops, cell phones and other wireless devices while the mesh routers forward traffic to and from the gateways which may but need not connect to the Internet. The coverage area of the radio nodes working as a single network is sometimes called a mesh cloud. Access to this mesh cloud is dependent on the radio nodes working in harmony with each other to create a radio network. Wireless mesh networks can be implemented with various wireless technology including 802.11, 802.15, 802.16, cellular technologies or combinations of more than one type.

Wireless Sensor Networks (WSN)

A wireless sensor network (WSN) consists of spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, humidity, motion or pollutants and to cooperatively pass their data through the network to a main location. The more modern networks are bi-directional, also enabling control of sensor activity. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance; today such networks are used in many industrial and consumer applications, such as industrial process monitoring and control, machine health monitoring, and so on.

Mobile Ad Hoc Network (MANET)

A mobile ad-hoc network is a self-configuring infrastructure less network of mobile devices connected by wireless links. Ad-hoc is Latin and means "for this purpose".

Each device in a MANET is free to move independently in any direction, and will therefore change its links to other devices frequently. Each must forward traffic unrelated to its own use, and therefore be a router. The primary challenge in building a MANET is equipping each device to continuously maintain the information required to properly route traffic. Such networks may operate by themselves or may be connected to the larger Internet.

AD-HOC NETWORK

An ad-hoc network is a local area network (LAN) that is built spontaneously as devices connect. Instead of relying on a base station to coordinate the flow of messages to each node in the network, the individual network nodes forward packets to and from each other. An ad hoc network typically refers to any set of networks where all devices have equal status on a network and are free to associate with any other ad hoc network devices in link range. Very often, ad hoc network refers to a mode of operation of IEEE 802.11 wireless networks. It also refers to a network device's ability to maintain link status information for any number of devices in a 1 link (aka "hop") range, and thus this is most often a Layer 2 activity.

Because this is only a Layer 2 activity, ad hoc networks alone may not support a route able IP network environment without additional Layer 2 or Layer 3 capabilities.

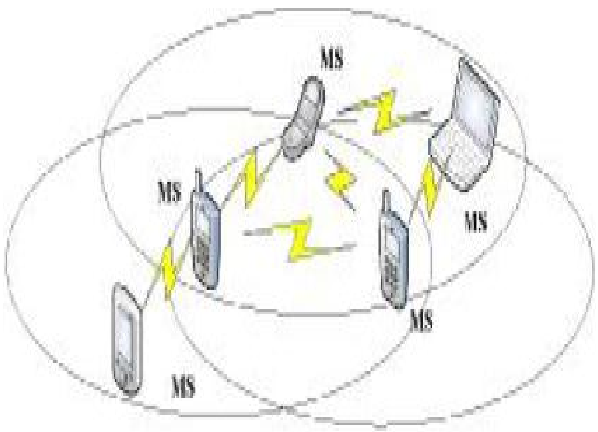

Fig4.Ad hoc Architecture

MAC with pilot CSI algorithm

The proposed CSI-aided strategy randomizes sensing decisions it is still possible for several SUs to choose the same channel. However, when an idle channel is found, only one of the SUs that have participated in sensing this channel can successfully transmit. To avoid SU collisions, perfect access decision resolution after sensing has been adopted .Pilot-based CSI prediction method is developed to enable the proposed CSI-aided sensing strategies for mobile scenarios. The proposed strategies can adapt to slowly varying long-term (shadow) fading CSI. A continuous-time Markov process (CTMP) is a collection of variables indexed by a continuous quantity, time. It obeys the Markov property that the distribution over a future variable is independent of past variables given the state at the present time.

Algorithm:

Step 1: **function** COMPUTEBEHAVIOR
Step 2: **input**
Step 3: D = (X, α, ^, Δ) : delay CTMC
Step 4: p_o: initial probability distribution
Step 5: n : time count
Step 6: W : number of workers
Step 7: $C^1, \ldots, C^W \subseteq \mathcal{C}^{[X,\alpha]}$
Step 8: **assume**
Step 9:

$$C^1 \uplus \cdots \uplus C^W = \mathcal{C}^{[X,\alpha]}$$
$$\forall c, c' \in \mathcal{C}^{[X,\alpha]} \exists i.\ (c_w = c'_w \Rightarrow \{c, c'\} \subseteq C^i)$$

Step 10: **output**
Step 11: $p_1, \ldots p_n$: probability distributions
Step 12: **begin**
Step 13: **for** each i∊ 1,. . .W do
Step 14: $p_0^i := p_0 \mid C^i$
Step 15: **done**
Step 16: LAUNCHANDWAIT(WORKER, W)
Step 17: **for** each k ∊ 1. . n do
Step 18: $p_k := p_k^i \cup \ldots \cup p_k^w$
Step 19: **done**
Step 20: **end**

IV. RESULT

The energy efficiency, minimum power and achievable rate of the secondary network over Rayleigh fading channels under spectrum sharing and sensing schemes.

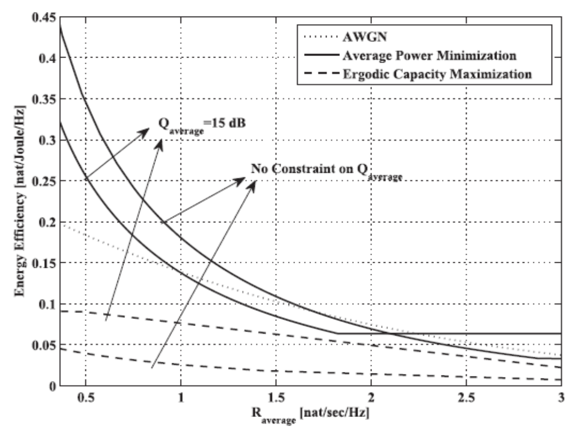

Fig 5.Energy Efficiency for average power minimization problem

Introduce continuous-time Mar

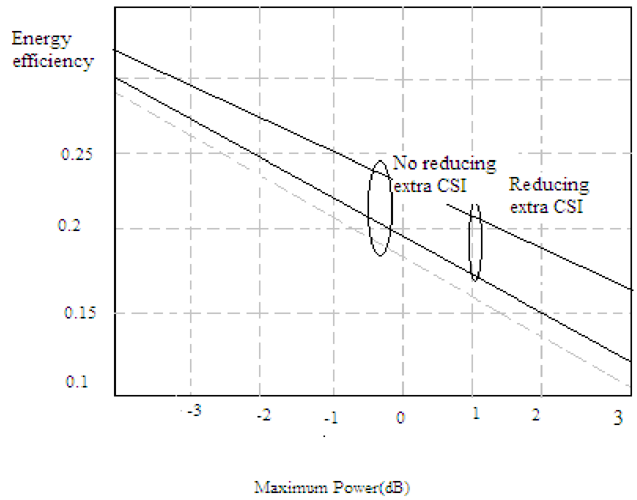

Fig 6 Energy Efficiency vs Maximum Power with multiple secondary link

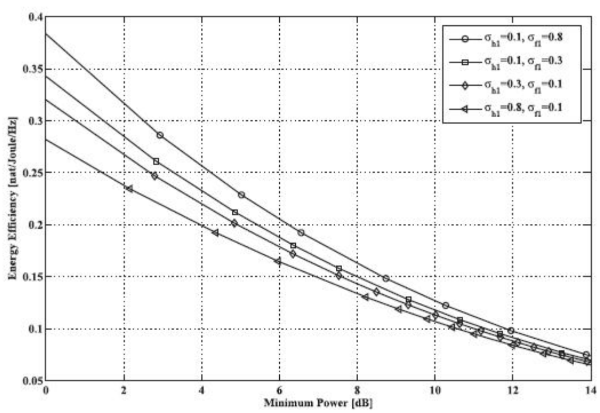

Fig. 6. The impact of varying σ_{h_1} and σ_{f_1} on the energy efficiency with $\rho = 5$ dB and $Q_{\text{average}} = 12$ dB

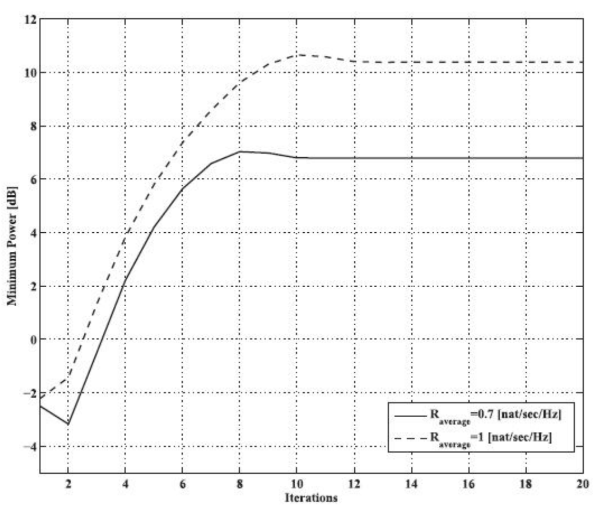

Fig. 7. The sum of minimum power of secondary transmitters versus the number of iterations for multiple secondary links in power control algorithm

V. CONCLUSION AND FUTURE WORK

CONCLUSION

Cognitive Radio (CR) is an adaptive, intelligent radio and network technology that can automatically detect available channels in a wireless spectrum. From the simulation results we can conclude that, the proposed MAC with pilot CSI algorithm provides better performance compared to conventional algorithms which can achieve more reliability, higher energy efficiency, less bit error rate (BER) and also achieve a good efficiency between channel capacity and interference in cognitive radio networks with low computational complexity.

FUTURE WORK

Cognitive Radio (CR) is an adaptive, intelligent radio and network technology that can automatically detect available channels in a wireless spectrum. From the simulation results we can conclude that, the proposed MAC with pilot CSI algorithm provides better performance compared to conventional algorithms which can achieve more reliability, higher energy efficiency, less bit error rate (BER) and also achieve a good efficiency between channel capacity and interference in cognitive radio networks with low computational complexity.

REFERENCES

[1] C. Xiong, L. Lu, and G. Y. Li, “Energy-efficient spectrum access in cognitive Radio ,” IEEE J. Sel. Communication., vol. 32, no. 3, pp. 550–562, Mar. 2014.

[2] C. Xiong, G. Y. Li, S. Zhang, Y. Chen, and S. Xu, “Energy- and spectral efficiency tradeoff in downlink OFDMA networks,” IEEE Trans. Wireless Commun., vol. 10, no. 11, pp. 3874–3886, Nov. 2011.

[3] G. Miao, N. Himayat, and G. Y. Li, “Energy-efficient link adaptation in frequency-selective channels,” IEEE Trans. Commun., vol. 58, no. 2, pp. 545–554, Feb. 2010.

[4] G. Ozcan and M. C. Gursoy, “Energy-efficient power adaptation for cognitive radio systems under imperfect channel sensing” in Proc. IEEE INFOCOM Workshop, Apr. 2014, pp. 706–711.

[5] S. Eryigit, G. Gur, S. Bayhan, and T. Tugcu, “Energy efficiency is a subtle concept: Fundamental trade-offs

for cognitive radio networks," IEEE Commun. Mag., vol. 52, no. 7, pp. 30–36, Jul. 2014.

[6] C. Jiang, H. Zhang, Y. Ren, and H. H. Chen, "Energy-efficient non cooperative Cognitive radio networks: Micro, meso, and macro views," IEEE Communication. Mag., vol. 52, no. 7, pp. 14–20, Jul. 2014.

[7] Y. Lu and A. Duel-Hallen, "Channel-adaptive sensing strategy for cognitive radio ad hoc networks," in Proc. IEEE CCNC, 2013, pp. 466–471.

[8] J. Jia, Q. Zhang, and X. Shen, "HC-MAC: A hardware-constrained cognitive MAC for efficient spectrum management," IEEE J. Sel. AreasCommun., vol. 26, no. 1, pp. 106–117, Jan. 2008.

[9] I. F. Akyildiz, W. Y. Lee, and K. R. Chowdhury, "CRAHNs: Cognitive radio ad hoc networks," Ad Hoc Netw., vol. 7, no. 5, pp. 810–836,Jul. 2009.

[10] L. Lai, H. E. Gamal, H. Jiang, and H. V. Poor, "Cognitive medium access: Exploration, exploitation, and competition," IEEE Trans. MobileComput., vol. 10, no. 2, pp. 239–253, Feb. 2011.

[11] Q. Zhao, L. Tong, A. Swami, and Y. Chen, "Decentralized cognitive MAC for opportunistic spectrum access in ad hoc networks: A POMDP framework," IEEE J. Sel. Areas Commun., vol. 25, no. 3, pp. 589–600, 2007.

[12] A. Jia, L. Cheng, The technique of digital detailed reservoir characterization, Petroleum Explo- ration and Development 37(2010) 709-715.

[13] S. Haykin, Cognitive Radio: Brain-Empowered Wireless Communications, IEEE Journal on Se- lected Areas in Communications 23(2005).

[14] M. C. Lucas-Estan, J. Gozalvez, On the Real-Time Hardware Implementation Feasibility of Joint Radio Resource Management Policies for Heterogeneous Wireless Networks, IEEE Transactions on Mobile Computing Vol(2013) 193-205.

[15] U.S. Dept. of Commerce, National Telecommunications and Information Administration, Office of Spectrum Management, "United States frequency allocations: The radio spectrum," Oct. 2003.

[16] Federal Communications Commision, "Spectrum policy task force report," Tech. Rep. 02-155, Nov. 2002.

[17] FCC, "Facilitating opportunities for flexible, efficient, and reliable spectrum use employing cognitive radio technologies," Notice of proposed rule making and order, FCC 03-322, Dec. 2003.

[18] Q. Zhao and B. M. Sadler, "A survey of dynamic spectrum access: Signal processing, networking, and regulatory policy," IEEE Signal Process. Mag., vol. 24, no. 3, pp. 79–89, May 2007.

[19] S. Haykin, "Cognitive radio: Brain-empowered wireless communications," IEEE J. Sel. Commun., vol. 23, no. 2, pp. 201–220, Feb. 2005.

[20] A. Goldsmith, S. Jafar, I. Maric, and S. Srinivasa, "Breaking spectrum gridlock with cognitive radios: An information theoretic perspective," Proc. IEEE, vol. 97, no. 5, pp. 894–914, May 2009. channels in fading environments," IET Commun., vol. 2, no. 6, pp. 724–732, Jul. 2008.

[21] M. Webb et al., Smart 2020: Enabling the Low Carbon Economy in the Information Age. London, U.K.: The Climate Group, 2008.

[22] Y. Chen, S. Zhang, S. Xu, and G. Y. Li, "Fundamental trade-offs on green wireless networks," IEEE Commun. Mag., vol. 49, no. 6, pp. 30–37, Jun. 2011.