International Journal of Systems Engineering
2017; 1(1): 17-20
http://www.sciencepublishinggroup.com/j/ijse
doi: 10.11648/j.ijse.20170101.13

A Spectrum Access with User Cooperation in Heterogeneous Cognitive Radio Networks

Saranya Sakthivel

Department of Computer Science and Engineering, SNS College of Engineering, Coimbatore, India

Email address:
ssaranya065@gmail.com

To cite this article:
Saranya Sakthivel. A Spectrum Access with User Cooperation in Heterogeneous Cognitive Radio Networks. *International Journal of Systems Engineering*. Vol. 1, No. 1, 2017, pp. 17-20. doi: 10.11648/j.ijse.20170101.13

Received: March 12, 2017; **Accepted**: May 20, 2017; **Published**: July 14, 2017

Abstract: Cognitive radio system consists of multiple wireless accesses that cover overlapping area, and cognitive terminals that use one or more of the wireless accesses simultaneously. In cognitive radio systems, secondary users can share the spectrum with the primary user as long as the quality of service (QoS) of the primary system is guaranteed. However, the system throughput of the cognitive system will be limited when the QoS requirement is stringent. We had proposed the architecture of the cognitive radio system, the inter-system handover protocols and packet format designed to achieve fast handover among the radio systems.

Keywords: Cognitive Radio Networks, Logarithmic Regret, Distributed Algorithms, Handovers, QoS

1. Introduction

Cognitive radio is an area of extensive research in communications, signal processing and networking [1]. Typically, there are two kinds of transmitting nodes in a cognitive network viz., the primary users who have priority in accessing the spectrum and the secondary users who only opportunistically access the spectrum when the primary user is idle [2]. The secondary users are cognitive and can sense the spectrum before transmission. They take advantage of the empty spaces in the spectrum and use them for transmissions, thus improving spectral efficiency. However, due to resource and hardware constraints, they can sense only a part of the spectrum at any given time.

In cognitive radio systems, the unlicensed (cognitive) users can access the licensed (primary) spectrum as long as the QoS of the licensed user is guaranteed [3]. With the Federal Communications Commission’s (FCC) spectrum policy reform, a new metric, called the interference temperature, has been proposed to quantify and manage the interference in a radio environment. However, the coexistence constraint, such as power levels for the cognitive users, should [4] be well predefined to maintain a guarantee of service to the primary users on the same band [5]. Under the scenario when the QoS requirement for the primary system is stringent, the throughput of the cognitive System will be limited due to the low allowed transmitting power level. Our contributions are three fold. First, we propose two distributed learning and allocation schemes for arbitrary numbers of [6] secondary users and channels. The first scheme assumes minimal prior information in terms of pre-allocated ranks for secondary users while the second scheme is fully distributed and assumes no such prior information. Second, we derive upper bounds on the sum regret under the proposed schemes. Third, we derive an asymptotic lower bound on the sum regret experienced by any distributed learning and allocation scheme satisfying a certain uniformly-good criterion. By comparing the lower and upper bounds, we conclude that our two proposed schemes are asymptotically efficient in terms of the order of number of slots.

The above tradeoffs in distributed learning and allocation among multiple secondary users have not been sufficiently examined in the literature before [7]. Our goal is to analyze these tradeoffs and propose schemes achieving provable optimal system throughput through only implicit cooperation among the secondary users. Based on these trends, we have studied a cognitive radio system that covers multiple wireless communication systems [8, 9, 10]. In this paper, we evaluate the system handover in a cognitive base station using the simulator based on proposed architecture of cognitive radio system.

The rest of this paper is organized as follows. In Section II, the system model is presented and the system input output relationship is derived. In Section III, the problem formulated. Furthermore, the power allocation is obtained and the beam weights are optimally selected. Simulation results are shown and discussed in Section IV. Finally, we will conclude our work in Section V.

2. System Model & Formulation

We first consider the case where the secondary users have information in the form of an allocation order, prior to learning and transmission. But there is no other information exchange among the secondary users. In the next section, we drop this assumption of initial information and consider fully distributed schemes for learning and allocation [11]. The assumption of preallocated ranks simplifies design since there is no need for the users to cooperatively arrive at an allocation order during the process of learning.

Instead, any policy under pre-allocation only needs to ensure that the users learn the channel availabilities accurately and occupy channels according to their reassigned ranks. Moreover, pre-allocated ranks can incorporate heterogeneous secondary users with different priority rankings. Pre-allocated ranks can be either provided by a central authority (base station) or arrived in a distributed manner through information exchange and consensus. For instance, each user generates a uniform random variable in [12, 13] and exchanges it with all other users. The ranks are then based on the order of the variables.

Cognitive radio has two trends. One is “Multiple System”, which switches wireless communication systems according to the radio conditions [14, 15]. The other is the so-called “Dynamic Spectrum Access”, which recognizes spare frequencies of a primary system and allocates them to be used for communication of a secondary system, to such an extent that it would not affect the primary system. We have studied a cognitive radio system based on the “multiple system” concept [16].

In our cognitive radio system, we assume the use of multiple frequencies of multiple wireless communication systems. Time ratio of frequency utilization varies widely according to location, time, a day of week, wireless communication system and communication carrier company, etc. By using these spare radio resources adaptively, the time ratio of frequency utilization can be increased.

We have provided four requirements to realize cognitive radio shown below [9].

1. System architecture for fast system handover.
2. One local IP address assignment to the terminal regardless the number of the wireless communication systems that the terminal communicates with.
3. The area of cognitive base station is the same as the area of the EVDO system, which covers the widest area among the other wireless systems.
4. Cognitive base station consists of the function of access point of EVDO, WiMAX and wireless LAN in the cognitive base station area, and control node to integrate these functions.

3. System Architecture

The system architecture based on the concept of multiple system cognitive radio As wireless communication systems, we adopted three systems: The first is EVDO Rev. 0, one of the cellular system with great expectation, and the second is WiMAX, one of the candidates of wireless broadband system for metropolitan area, and the third is wireless LAN, the most popular wireless communication system in office and indoor environment. Cognitive base station consists of multiple access points of EVDO, WiMAX and wireless LAN, monitoring node and control node [17]. Monitoring node collects various kinds of radio information from each wireless communication system, and calculates statistical value to recognize the radio condition. Control node switches wireless communication system according to the information from the monitoring node. Cognitive terminal consists of access terminal function of EVDO, WiMAX CPE function, access terminal function of wireless LAN, control node to converge the data received from these three systems and monitor terminal to display the streaming data delivered.

Cognitive terminal switches the wireless communication system frequently according to the radio conditions. Therefore in the cognitive radio, it would be required that the corresponding node needs not to know which wireless system is being used. In our system, each terminal has only on local IP address regardless the number of the wireless communication systems that the terminal communicates with.

4. Results and Discussion

In this section, some simulation results are presented to illustrate the system performance of our proposed approach. Throughout this section, we will assume that the system parameters are set as follows. However, it must be noted that our contributions are not dependent on these parameters. Cognitive source and destination are located at coordinates (0m, 0m) and (80m, 0m), respectively; M potential relays are randomly located within a rectangular area which is described by (0m, 10m), (0m, -10m), (100m, 10m), (100m, -10m); Primary transmitter and receiver are set at coordinates (0m, -10m) and (10m, -10m), respectively; drop the assumption of prior agreement among the secondary users on the allocation order for accessing channels and design a fully distributed policy for learning and allocation without any information exchange. We show that logarithmic growth of regret is possible by adaptively changing the channel selection based on collisions experienced in the previous time slots. To this end, we use a different method for estimating the rank of a channel, than the greedy scheme used in previous section where randomization with parameter _n is employed. We instead compute the so-called g-statistic for each channel, and the estimated ranks are based on the order of g-statistics of different channels. Based on the system architecture in section 3, we have developed a simulator that supports EVDO, WiMAX and Wireless LAN. In the simulator, monitoring node monitors RSSI (received signal strength indicator) values and calculates moving average of collected RSSI values, and control node switches to the communication system that has maximum RSSI value. Locations of Access points of each wireless system and direction where cognitive terminal moves are shown in Figure 1

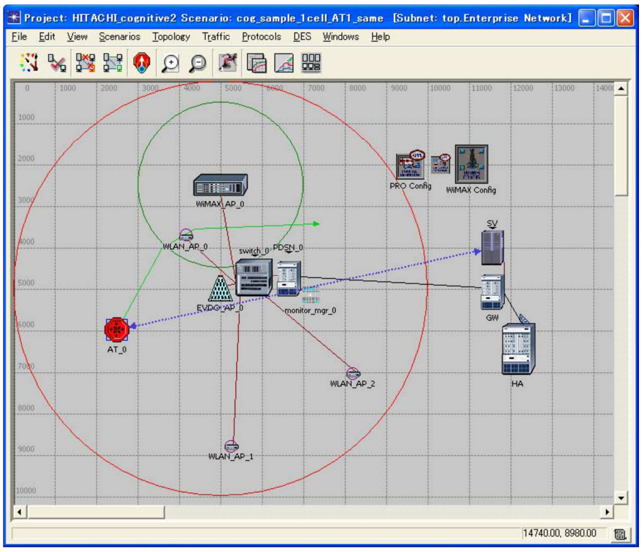

Figure 1. *Simulation overview.*

Highest RSSI value shown in figure 1. Moreover, shows that the data transmission rate is still kept regardless the system switching, and that stream data can be delivered continuously without any effects of handovers. We proved the effect of using cognitive radio system. In this paper, we utilize RSSI value as radio environmental information for system handover, but it is not enough to realize optimal services for users. For next step, we will add the information such as interference, system throughput and system priority of system selected by users according to their services. In the near future, we will develop the system hand over that considers not only radio environment information but also system load, that is expected to improve system throughput.

5. Conclusion

The problem of adaptive user cooperation in heterogeneous cognitive radio systems has been studied. Coexistence between the cognitive system and the primary system was allowed as long as the interference constraint for the primary receiver was guaranteed. In this paper, we described the simulator that supports EVDO, WiMAX and wireless LAN based on proposed cognitive radio system architecture, and evaluated inter system handover in the area covered with one cognitive base station. Through the simulation, we have proved that communication systems switches appropriately according to movement of cognitive terminal and transmission data can be delivered continuously without any effects of hand overs. For the next step, we will add other than RSSI as radio environmental information, and develop the system handover with improvement of system throughput.

References

[1] Ian F. Akyildiz, Won-Yeol Lee, Mehmet C. Vuran, and Shantidev Mohanty, “A Survey on Spectrum Management in Cognitive Radio Networks”, IEEE communications magazine, April 2008.

[2] Qing-qi Pei, Zili, and Li-chuna ma, “A Trust Value – Based Spectrum Allocation Algorithm in CWSNs”, Hindawi Publishing Corporation, International Journal of Distributed Sensor Networks, volume April 2013.

[3] Hyunsung Kim, “privacy preserving security framework for cognitive radio networks”, department of cyber security, Kyungil University, Korea, mar-apr 2013.

[4] FCC, ET Docket No 03-222 Notice of proposed rulemaking and order, December 2003.

[5] J. Mitola III, “cognitive radio: an integrated agent architecture for software defined radio”, PhD. Thesis, KTH Royal Institute of Technology, 2000.

[6] Didem Gozupek, Suzan Bayhan, and Fatih Alagoz, “A Novel Handover Protocol to Prevent Hidden Node Problem in Satellite Assisted Cognitive Radio Networks”, satellite networks research laboratory (SATLAB), dept of computer engineering, Bogazici University, TURKEY, 2008.

[7] Elias Z. Tragos, Sherali Zeadally, Alexandros G. Fragkiadakis, and Vasilios A. Siris,”Spectrum Assignment in Cognitive Radio Networks: A comprehensive Survey, IEEE communication surveys & tutorials, vol. 15, no. 3, third quarter 2013.

[8] L. Qiu, Y. Zhang, F. Wang, and M. Han, “A general model of wireless interference”, in proc. 13th annual ACM international conference on Mobile computing and networking, 2007.

[9] J. Lee, S. Lee, W. Kim, D. Jo, T. Kwon, and Y. Choi, “understanding interference and carrier sensing in wireless mesh networks”, IEEE commun. Mag., vol. 47, no. 7, pp. 102-109, 2009.

[10] S. Bayhan, G. Gur, F. Alagoz, “satellite assisted spectrum agility concept”, proceedings of military communications conference (MILCOM’07), Orlando, Florida, USA, 2007.

[11] K. Mythili and H. Anandakumar, "Trust management approach for secure and privacy data access in cloud computing," Green Computing, Communication and Conservation of Energy (ICGCE), 2013 International Conference on, Chennai, 2013, pp. 923-927. doi: 10.1109/ICGCE.2013.6823567.

[12] V. Dhivya, H. Anandakumar and M. Sivakumar, "An effective group formation in the cloud based on Ring signature," Intelligent Systems and Control (ISCO), 2015 IEEE 9th International Conference on, Coimbatore, 2015, pp. 1-4. doi: 10.1109/ISCO.2015.7282366.

[13] A. Roshini and H. Anandakumar, "Hierarchical cost effective leach for heterogeneous wireless sensor networks," Advanced Computing and Communication Systems, 2015 International Conference on, Coimbatore, 2015, pp. 1-7. doi: 10.1109/ICACCS.2015.7324082.

[14] H. Anandakumar and K. Umamaheswari, “Energy Efficient Network Selection Using 802.16g based GSM Technology” J. Comput. Sci., vol. 10, no. 5, pp.745-754. (2014) doi: 10.3844/jcssp.2014.745.754.

[15] S. Divya, H. A. Kumar and A. Vishalakshi, "An improved spectral efficiency of WiMAX using 802.16G based technology," Advanced Computing and Communication Systems, 2015 International Conference on, Coimbatore, 2015, pp. 1-4. doi: 10.1109/ICACCS.2015.7324098.

[16] M. Suganya and H. Anandakumar, "Handover based spectrum allocation in cognitive radio networks," Green Computing, Communication and Conservation of Energy (ICGCE), 2013 International Conference on, Chennai, 2013, pp. 215-219. doi: 10.1109/ICGCE.2013.6823431.

[17] Diego Pacheco-Paramo, Vicent Pla and Jorge Martinez-Bauset, “optimal admission control in cognitive radio networks”, dept. of communication, Universidad Politecnica de Valencia (UPV), 2009.