International Journal of Current Trends in Engineering & Technology
ISSN: 2395-3152
Volume: 03, Issue: 03 (MAY– JUNE, 2017)

A Survey of Distributed Soft Decision Weighted Cooperative Sensing in Cognitive Radio Networks

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Abstract—* in cognitive radio transceiver can smartly recognize which communication channels are in used. Cognitive radio is a type of wireless communication. The unused channels are used instead of used channels. Cognitive radio enhances the use of vacant radio-frequency range while reducing interference to additional users. Spectrum reorganization is a significant purpose of cognitive radio to stop the destructive interfering with certified users and recognize the vacant spectrum for improving the range's consumption. In a cooperative cognitive radio spectrum recognizing scheme, recognizing will be commenced by an amount of dissimilar radios inside a cognitive radio network. The weighted average distributed consensus-based combination allows each SU to pick out a weight permitting to the measurement situation, and the comprehensive attached measurement is a soft weighted linking reflecting the measurement superiority without consolidated fusion point. In this paper, the state-of-the-art survey of distributed cooperative sensing is provided to address the issues of cooperation gain, cooperation method, and cooperation overhead. This paper also discusses the soft decision in distributed cooperative spectrum sensing.

Keywords— Cognitive radio, Spectrum sensing, weighted average consensus, Soft decision, Signal detection

I. INTRODUCTION

Wireless system technology [1] is proliferating speedily, and the apparition of ubiquitous wireless communications and computing proposals the promise of numerous individual and social benefits. This explosion of wireless device applications generates an ever-increasing request for extra radio spectrum. Though, furthermost with no concern working spectrum bands have been allocated, even though numerous studies have exposed that these bands are expressively underutilized. These considerations have inspired the search for revolution of radio technologies that can scale to come across forthcoming demands both in terms of application performance and spectrum efficiency [2]. The radio frequency spectrum is an inadequate resource with countless and great importance. Deploying and building a network of cognitive radios is a complicated task. In a cooperative cognitive radio spectrum recognizing scheme, recognizing will be commenced by an amount of dissimilar radios inside a cognitive radio network. Cognitive radios [3] provide the promise of being a disrupting technology revolution that will permit the upcoming wireless world. Cognitive radios are entirely programmable wireless set of devices that can sense their surroundings and energetically adjust their channel access method, transmission waveform, networking protocols and spectrum use, as desired for decent application and network performance. Spectrum recognizing is a significant purpose of cognitive radio to stop the destructive interfering with certified users and recognize the vacant spectrum for improving the range's consumption. Cognitive radio permits user stations to intelligently sense whether a portion of the spectrum is being used in demand to share spectrum with closed neighbor users. The weighted average distributed consensus-based combination allows each SU to pick out a weight permitting to the measurement situation, and the comprehensive attached measurement is a soft weighted linking reflecting the measurement superiority without consolidated fusion point. The most essential procedures in cognitive radio are spectrum sensing, which permits the secondary users to perceive the occurrence of a primary user in the spectrum. Current research [4] advancement demonstrates that cooperative spectrum sensing is an encouraging procedure to increase the spectrum sensing performance under fading, shadowing and time-varying wireless channels. Recent research on cooperative sensing is concentrated on numerous areas containing the designing of optimal link budget, optimal detector for sensing, and inventing novel models and communication approaches to perceive primary transmitter and distance-user adjustment in interrelated fading situation. This paper reviewed the various distributed weighted soft decision [5] method in cognitive radio for spectrum sensing. By giving weight to the soft decision of separate sensing, communication can moderate the possibility of disappeared white spaces while provided that the primary receiver with its anticipated level of interference-protection by means of less numeral of cooperating users than prevailing structure. This paper discussed the soft decision weighted distributed cooperative spectrum sensing in cognitive radio.

Paper is organized as follows. Section II provides background of cognitive radio. Section III provides details of cooperative spectrum sensing in cognitive radio network. Section IV provides literature survey of weighted distributed soft decision in cognitive radio networks. Section V concludes the paper.

II. BACKGROUND OF COGNITIVE RADIO

Cognitive radio (CR) is a form of wireless communication in which a transceiver can intelligently detect which communication channels are in use and which are not, and instantly move into vacant channels while avoiding occupied ones. Cognitive radio optimizes the use of available radio-frequency (RF) [6] spectrum while minimizing interference to other users. Cognitive radios have the ability to monitor, sense, and detect the conditions of their operating environment, and dynamically reconfigure their own characteristics to best match those conditions. Unlike their traditional counterparts, they can view their environment in great detail to identify spectrum that is not being used, and quickly tune to that frequency to transmit and/or receive signals. They also have the ability to instantly find other spectrum if interference is detected on the frequencies being used. Possible functions [7] of cognitive radio include the ability of a transceiver to determine its geographic location, identify and authorize its user, encrypt or decrypt signals, sense neighboring wireless devices in operation, and adjust output power and modulation characteristics. There are two main types of cognitive radio, full cognitive radio and spectrum-sensing cognitive radio. Full cognitive radio takes into account all parameters that a wireless node or network can be aware of. Spectrum-sensing [8] cognitive radio is used to detect channels in the radio frequency spectrum. In common the cognitive radio might be predictable to look at parameters such as free channels, channel occupancy, the kind of data to be communicated and the modulation styles that may be used. It must similarly look at the directing necessities. The use of a cognitive radio network provides [9] a number of advantages when compared to cognitive radios operating purely autonomously: (1) improved spectrum sensing: By using cognitive radio networks, it is possible to gain significant advantages in terms of spectrum sensing. Improved coverage: (2) by setting up cognitive radio network, it is possible to relay data from one node to the next. In this way power levels can be reduced and performance is maintained. The idea for cognitive radio has come out of the need to utilize the radio spectrum more efficiently, and to be able to maintain the most efficient form of communication for the prevailing conditions. By using the levels of processing that are available today, it is possible to develop a radio that is able to look at the spectrum, detect which frequencies are clear, and then implement the best form of communication for the required conditions. In this way cognitive radio technology is able to select the frequency band, the type of modulation, and power levels most suited to the requirements, prevailing conditions and the geographic regulatory requirements.

Features of cognitive radio networks include:

- Sensing the current radio frequency spectrum environment: This includes measuring which frequencies are being used, when they are used, estimating the location of transmitters and receivers, and determining signal modulation. Results from sensing the environment can be used to determine radio settings.
- Policy and configuration databases: Policies specifying how the radio can operate and physical limitations of radio operation can be stored in the radio or made available over the network. Policies might specify which frequencies can be used in which locations. Configuration databases would describe the operating characteristics of the physical radio. These databases would normally be used to constrain the operation of the radio to stay within regulatory or physical limits.
- Self-configuration: Radios may be assembled from several modules. For example, a radio frequency front-end, a digital signal processor and a control processor. Each module should be self-describing and the radio should automatically configure itself for operation from the available modules. Some might call this "plug-and-play."
- Mission-oriented configuration: Software defined radios can meet a wide set of operational requirements. Configuring a SDR to meet a given set of mission requirements is called mission oriented configuration. Typical mission requirements might include operation within buildings, substantial capacity, operation over long distances, and operation while moving at high speed. Mission-oriented configuration involves selecting a set of radio software modules from a library of modules and connecting them into an operational radio.
- Adaptive algorithms: During radio operation, the cognitive radio is sensing its environment, adhering to policy and configuration constraints, and negotiating with peers to best utilize the radio spectrum and meet user demands.
- Distributed collaboration: Cognitive radios will exchange current information on their local environment, user demand, and radio performance

International Journal of Current Trends in Engineering & Technology
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between themselves on a regular basis. Radios will use their local information and peer information to determine their operating settings.

- Security: Radios will join and leave wireless networks. Radio networks require mechanisms to authenticate, authorize and protect information flows of participants.

III. COOPERATIVE SPECTRUM SENSING

In many areas cognitive radio systems coexist with other radio systems, using the same spectrum but without causing undue interference. When sensing the spectrum occupancy, the cognitive radio system must accommodate a variety of considerations: Continuous spectrum sensing: It is necessary for the cognitive radio system to continuously sense the spectrum occupancy. Typically a cognitive radio system will utilize the spectrum on a non-interference basis to the primary user. Accordingly it is necessary for the Cognitive radio system to continuously sense the spectrum in case the primary user returns. Monitor for alternative empty spectrum: In case the primary user returns to the spectrum being used, the cognitive radio system must have alternative spectrum available to which it can switch should the need arise. Monitor type of transmission: It is necessary for the cognitive radio to sense the type of transmission being received. The cognitive radio system should be able to determine the type of transmission used by the primary user so that spurious transmissions and interference are ignored as well as transmissions made by the cognitive radio system itself.

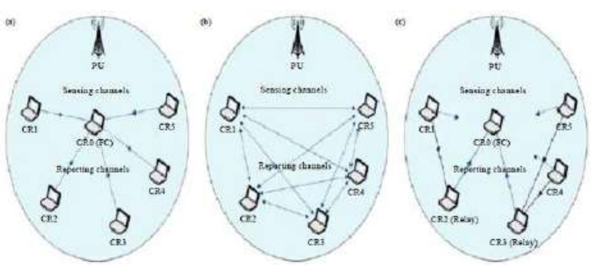

Figure1: Classification of cooperative sensing (a) Centralized (b) Distributed (c) relay-assisted

There are a number of ways in which cognitive radios are able to perform spectrum sensing. The ways in which cognitive radio spectrum sensing can be performed falls into one of two categories: ***Non-cooperative spectrum sensing:*** This form of spectrum sensing, occurs when a cognitive radio acts on its own. The cognitive radio will configure itself according to the signals it can detect and the information with which it is pre-loaded. ***Cooperative spectrum sensing:*** Within a cooperative cognitive radio spectrum sensing system, sensing will be undertaken by a number of different radios within a cognitive radio network. Typically a central station will receive reports of signals from a variety of radios in the network and adjust the overall cognitive radio network to suit. Cognitive radio cooperation reduces problems of interference where a single cognitive radio cannot hear a primary user because of issues such as shading from the primary user, but a second primary user acting as a receiver may be able to hear both the primary user and the signal from the cognitive radio system.

The cooperative sensing is classified as distributed sensing, centralized sensing and relay-assisted sensing. Distributed cooperative sensing does not rely on a fusion central for making the cooperative decision. In centralized cooperative sensing fusion central controls the process of cooperative sensing. In distributed cooperative sensing cognitive user communicate among them and converge to a unified decision on the presence or absence of PUs by iterations. In relay assisted cooperative sensing CR user observing a weak sensing channel and a strong report channel and a CR user with a strong sensing channel and a weak report channel, for example, can complement and cooperate with each other to improve the performance of cooperative sensing.

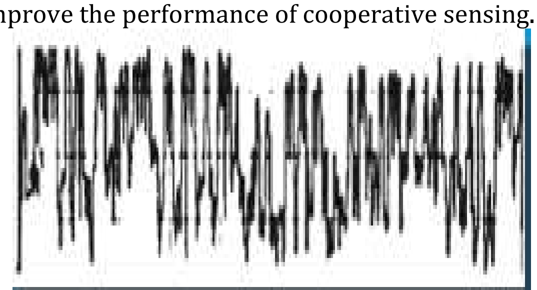

Figure 2: Conventional radio spectrum view

Conventional radio view of unlicensed spectrum shows radio spectrum as a wall of interference. This spectrum analyzer reading shows how conventional radios show congested radio spectrum with heavy interference, and essentially unusable.

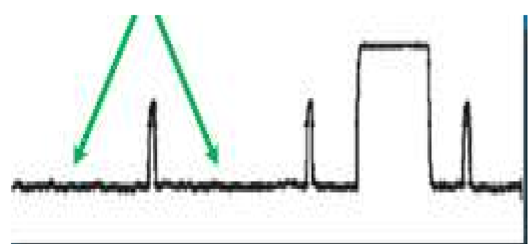

Figure 3: Cognitive radio spectrum view

Cognitive radio view of unlicensed spectrum sees radio spectrum as a window of opportunity. Cognitive radio can view the same radio spectrum in deeper detail, allowing them to identify unused gaps to transmit signals. The open challenges regarding cooperation models include the following: Modeling of cooperation overhead: Most existing models for cooperative sensing are centered at the detection performance that is cooperative gain. Only a few cooperation overhead issues have been discussed in proposed schemes. For example, in [10], only the number of cooperating CR users and the sensing time throughput tradeoff are considered in forming utility functions. While cooperative gain is important in the model, proper modeling of cooperation overhead can reveal realistic achievable cooperative gain. Thus, the modeling of cooperation overhead is still an open challenge in the modeling for cooperative sensing. Modeling of primary user cooperation: Most existing models for cooperative sensing focus on the detection of a single large-scale PU such as a TV base station and assume that the PUs do not cooperate with CR users. However, in certain applications such as military CR networks, these assumptions may not be true, since the PUs may be motivated to cooperate with CR users and the PUs may be connected in an ad hoc manner. As a result, new models that model the cooperation between PUs and CR users for cooperative sensing and cooperative communications such as the one in [11] are desired. In addition, the detection of small-scale mobile PUs such as wireless microphones is a known open challenging research problem, which will need a new model for cooperative sensing.

IV LITERATURE SURVEY

[12] Develop a distributed weighted combining scheme for cooperative spectrum sensing in cognitive radio networks. The proposed method is based on the weighted average consensus algorithm for both fixed and time-varying network graphs. Through the weighted local fusion iteration, each secondary user derives the global decision statistic from the weighted soft measurement combining throughout the network to achieve distributed cooperative spectrum sensing. When the weights are appropriately chosen, the detection performance of the proposed scheme is comparable to the performance of centralized optimal weighted combining scheme and outperforms existing distributed equal gain combining schemes. The author considers practical channel conditions and link failures, and develops new weighted soft measurement combining without a centralized fusion center. Following the measurement by its energy detector, each secondary user exchanges its own measurement statistics with its local one-hop neighbors, and chooses the information exchanging rate according to the measurement channel condition, e.g., the signal-to-noise ratio (SNR). The fundamental task of each CR user in CR networks, in the most primitive sense, is to detect the licensed users, also known as primary users (PUs), if they are present and identify the available spectrum if they are absent. This is usually achieved by sensing the RF environment, a process called spectrum sensing. The objectives of spectrum sensing are twofold: first, CR users should not cause harmful interference to PUs by either switching to an available band or limiting its interference with PUs at an acceptable level and, second, CR users should efficiently identify and exploit the spectrum holes for required throughput and quality-of service (Quos). Thus, the detection performance in spectrum sensing is crucial to the performance of both primary and CR networks.

[13] Introduce a new cooperative spectrum sensing technique which considers the spatial variation of secondary (unlicensed) users and each user's contribution is weighted by a factor that depends on received power and path loss. Compared to existing techniques, the proposed one increases the sensing ability and spectrum utilization, and offers greater robustness to noise uncertainty. Moreover, this cooperative technique uses very simple energy detector as its building block thereby reduces the cost and operational complexity.

The author proposes a new combining method (weighted combining) that incorporates simple energy detector for user cooperation by considering the spatial variations of the users; ii) with the same number of cooperating users in independently faded channels, the proposed method detects the presence of primary user with higher probability than the existing combining methods iii) achieves higher spectrum utilization and elevated agility with lower observation time, bandwidth and SNR requirements and iv) requires less number of users to achieve a given detection probability. The detection performance can be primarily determined on the basis of two metrics: probability of false alarm, which denotes the probability of a CR user declaring that a PU is present when the spectrum is actually free, and probability of detection, which denotes the probability of a CR user declaring that a PU is present when the spectrum is indeed occupied by the PU. Since a miss in the detection will cause the interference with the PU and a false alarm will reduce the spectral efficiency, it is usually required for optimal detection performance that the probability of detection is maximized subject to the constraint of the probability of false alarm.

[15] proposed an improved cooperative-sensing based opportunistic spectrum access under fading and shadowing, and theoretically formulated probability of detection and false alarm rate for each case. As indicated by the presented analyses, user collaboration in the proposed way result in significant enhancements in detection and spectrum utilization over previously practiced EGC method. By employing weight to the decision of individual sensing, WC can diminish the

probability of missing white spaces while providing the primary receiver with its desired level of interference-protection using less number of cooperating users than existing scheme. The CROCs for AWGN, Rayleigh fading and lognormal shadowing obtained in [16] clearly demonstrate that the performance of cooperative sensing results in better spectrum utilization and lower interference probability under fading or shadowing than individual sensing. While this underpins the importance of cooperation in successful sensing, further improvement is needed for reliable deployment of cognitive radios.

V. CONCLUSION

A cognitive radio is a radio that can be configured dynamically and programmed to consume the finest wireless channels in its locality. The radio frequency spectrum is an inadequate resource with countless and great importance. Deploying and building a network of cognitive radios is a complicated task. Cognitive radios have the capability to sense, monitor, and detect the conditions of their operating environment, and dynamically reconfigure their own characteristics to best match those conditions. The most essential procedures in cognitive radio are spectrum sensing, which permits the secondary users to perceive the occurrence of a primary user in the spectrum. This paper reviewed the various distributed weighted soft decision method in cognitive radio for spectrum sensing. This paper discussed the soft decision weighted distributed cooperative spectrum sensing in cognitive radio.

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