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Centralized and Decentralized Cognitive Radio Network Optimization

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ABSTRACT

Cognitive Radio (CR) is an intelligent wireless communication system to solve spectral clogging problem and increasing bandwidth utilization for next generation wireless communication applications. Computationally and energy efficient spectrum sensing for detecting spectrum holes in wideband radio spectrum still remains a challenge. The cognitive nodes which are far away from primary user (PU) may not be able to detect the PU due to severe fading in channel. Here we proposed system is used to improve the efficiency of spectrum sensing in cooperative communication system based on cognitive relaying with amplify-and-forward (AF) and decode-and-forward (DF) using compressive measurement algorithms. Using relay nodes, the bit error rate (BER) reduces due to increase in the probability of detection. Employment of number of relay nodes reduces the sensing time, improves the quality of communication and increases throughput of system at reasonable complexity using compressive signal processing (CSP)

1, INTRODUCTION

Cognitive radio technology has been developed to improve radio resource usage of the wireless network environment. Recently, various wireless services have been widely deployed, and the amount of mobile traffic is continuously and rapidly increasing. To satisfy such a high demand for mobile communications, the capacity of mobile wireless networks has to be increased, requiring additional radio-frequency bands. However, most of the frequency bands suitable for mobile communications have already been assigned to existing wireless services, and the remaining bands are limited. Therefore, optimization of the radio resource usage of the wireless network is a very important issue in the current wireless networks. The key idea of cognitive radio is to efficiently utilize limited radio resources by dynamic spectrum access.

In conventional wireless systems, the radio access networks and spectrum bands are statically assigned to mobile systems. In such a case, a network or a frequency band maybe highly congested, while others have many available resources with low traffic. By dynamic use of the radio access networks or spectrum bands, usage of limited radio resources can be optimized, and the capacity and quality of the wireless systems can be highly improved. The original definition of cognitive radio [1], [2] is that it is a type of cognitive dynamic system [3]. Cognitive radio systems observe and recognize a radio network environment, make reconfiguration decisions, and apply the corresponding action to reconfigure the network. By this approach, various types of radio parameters in wireless communication systems can

The cognitive radio network architecture

Existing wireless network architectures employ heterogeneity in terms of both spectrum policies and communication technologies. Moreover, some portion of the radio spectrum is licensed for different technologies and some bands remain unlicensed (called Industrial Scientific Medical (ISM) band). A clear description of Cognitive Radio Network architecture is essential for the development of communication protocols. The components of the Cognitive Radio network architecture, as shown in Figure 1.1, can be classified in two groups such as the primary network and the CR network. The basic elements of the primary and the CR network are

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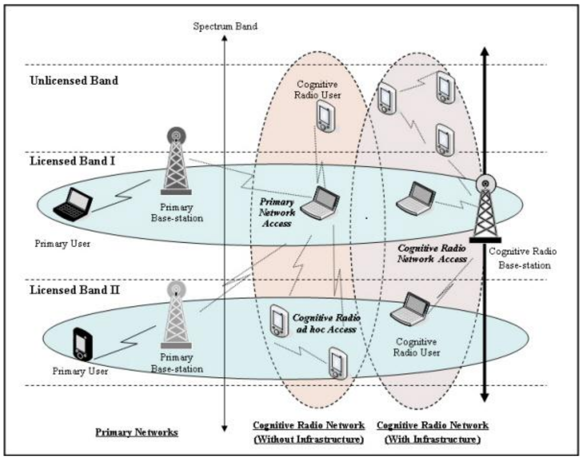
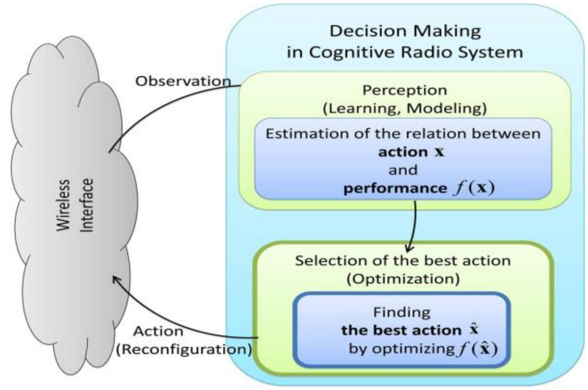
defined as followsbe optimized by appropriate actions



Cognitive system for heterogeneous wireless networks and its optimization problem

Cognitive System for Heterogeneous Wireless Networks Recently, several wireless communication standards based on the idea of cognitive radio have been developed. Under the IEEE802 standard, wireless local area networks (LANs), 802.11af [11], wireless broadband systems, 802.22 [12], and IEEE802.16h [13] have been developed as real services using cognitive radio technology, which utilize the white space of the TV spectrum bands. Such cognitive radio systems collect available spectrum resource information and select the most appropriate resources while avoiding interference with the primary wireless systems, which involve TV broadcasting. On the other hand, optimal selection of the best wireless service also improves the quality of wireless services by efficient radio resource usage, defined as the DRRUO in IEEE1900.4 [9]. In such wireless networks, the selection of the most appropriate action can be defined as an optimization problem when the improvement in quality can be estimated by the collected information. Figure 1.2 shows a general cognitive radio system, which can be applied to the systems described above.



Which may generate overhead for exchanging the context information and control information of the entire network? Therefore, in the second approach, we consider the application of distributed optimization algorithms, which run in parallel, for large-scale network optimization. As a cognitive radio system, which can be optimized by optimization algorithms, IEEE1900.4 defines the architecture to exchange the context information and the spectrum selection policy between the terminal side and the network side [9], whose management architecture is shown in Figure 1.3 The network reconfiguration manager (NRM) collects context information of the radio access networks (RAN) via the RAN measurement collector (RMC).

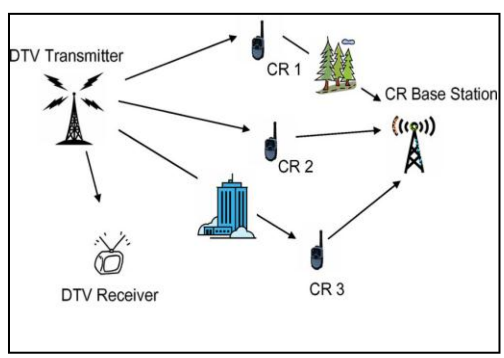
2, LITERATURE REVIEW

Cognitive radio technology improves radio resource usage by reconfiguring the wireless connection settings according to the optimum decisions, which are made on the basis of the collected context information. This paper focuses on optimization algorithms for decision making to optimize radio resource usage in heterogeneous cognitive wireless networks. For networks with centralized management, we proposed a novel optimization algorithm whose solution is guaranteed to be exactly optimal. In order to avoid an exponential increase of computational complexity in large scale wireless networks, we model the target optimization problem as a minimum cost-flow problem and find the solution of the problem in polynomial time. For the networks with decentralized management, we propose a distributed algorithm using the distributed energy minimization dynamics of the Hopfield–Tank neural network. Our algorithm minimizes a given objective function without any centralized calculation. We derive the decision-making rule for each terminal to optimize the entire network. We demonstrate the validity of the proposed algorithms by several numerical simulations and the feasibility of the proposed schemes by designing and implementing them on experimental cognitive radio network systems [1].

Cognitive Radio (CR) emerging approach which solves issues like spectrum scarcity and underutilization is resolved putting into effect the innovative ideas. FCC has announced a very interesting report in 2002, pointing out that more than 70% of the Radio Spectrums are underutilized at certain times or geographic positions, which proves that spectrum scarcity is not due to fundamental lack of spectrum instead because of waste of static spectrum allocation. In Non-Cooperative sensing has a very major limitation when a user experiences shadowing or fading effects under such situations, user cannot distinguish between an unused band and a deep fade. Collaborative spectrum sensing can be used to combat such effects. This paper deals with Cooperative Sensing using AND & OR Detection method and Trade-off point is calculated using simulation on precisely built Cognitive Radio MATLAB environment. Performance analysis using ROC curves taking into consideration the Probability of False alarm (Pfa) and Probability of Missed detection (Pmd) is done. This MATLAB Simulation analysis shows and intimate that in conditions where quick response is of great importance OR detection method leads with compromise over accuracy i.e more false alarms whereas AND detection method improve significantly the overall Cognitive system performance, bumping-off issues like Pfa in OR Detection method on the expense of delayed response. Best point is simulated out having acceptable accuracy and low latency period [3].

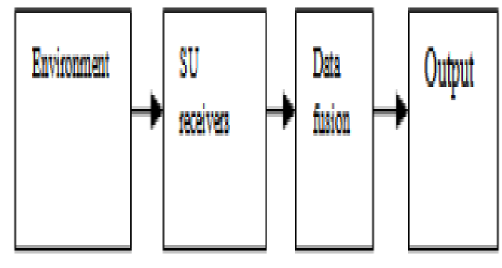
3, COOPERATIVE SPECTRUM SENSING

In a wireless network, the data to be transferred from sender to a receiver has to propagate through air. During this propagation the signal (data) gets distorted due to several phenomenon's that are present in its path (sender-receiver). Issues like hidden terminal problem, multi-path and shadowing, power consumption, robustness, and noise all makes it difficult to detect and extract the exact transmitted signal at the receiver. Cooperative sensing provides the solution to problems that arise in signal detection due to noise uncertainties, shadowing, and fading. The probability of miss-detection and the probability of false-alarm decrease considerably under cooperative sensing. Cooperative spectrum sensing plays an important role in cognitive radios network in order to improve the detection probability of licensed spectrum. Cooperative sensing also provides solution to hidden terminal problem and could also decrease the sensing time [6].



System model

The fleeting extension in wireless communications has come up to a huge desire on the deployment of advanced wireless services in both the licensed and unlicensed frequency spectrum. The basic idea behind cooperative transmission rests on the observation that, in a wireless environment, the signal transmitted or broadcast by a source to a destination node, each employing a single antenna is also received by other terminals, which are often referred to as relays or partner. In this paper, we propose durable cooperative spectrum sensing technique to address these challenging affair. With speedy and agile sensing ability, CR can opportunistically fill in spectrum holes to improve the spectrum occupancy utilization. However, once the PU returns to access the licensed band, the CR should immediately stop operating in the PU licensed band. This rapid switching off of the CR can guarantee least interference to the primary system. However, from the point of perspective of the cognitive system, the interruptive transmissions will lead to a discontinuous data service and intolerable delay. To manage with this complication, we propose a cognitive relay network in which distributed cognitive users participate each other so that they can divide their distinct spectrum bands. In this proposed method, centralized sensing is used to control the cognitive radio traffic. Based on the sensing results, unlicensed users should revamp their transmit powers and access strategies to protect the licensed communications. The requirement naturally presents challenges to the implementation of CR.



Methods of cooperative spectrum sensing

Cooperation can be among cognitive radios or external sensors can be used to build a cooperative sensing network. In the former case, cooperation can be implemented in two fashions: centralized, distributed and external Spectrum sensing are discussed in the following sections.

Optimization of cognitive radio networks by centralized management

In the combinatorial optimization problem in (2) for finding the optimum BS selections L, the number of combinations increases exponentially with the increase in the number of BSs. In this section, we show that the problem can be solved rigorously by the following algorithm, even for large-scale heterogeneous wireless networks. A. Rigorous Algorithm to Solve the Optimal State of the Cognitive Radio Network Our proposed approach is to formulate a combinatorial optimization problem as a network flow problem by modelling the system as a graph.

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We transform the heterogeneous BS selection problem in (2) to a minimum cost-flow problem, which can be rigorously solved with low computational complexity. The minimum cost-flow problem is to find the optimal flow z_e for each edge e in the graph G, $e \in E(G)$, by minimizing the entire cost in a directional graph. The following equation is minimized:

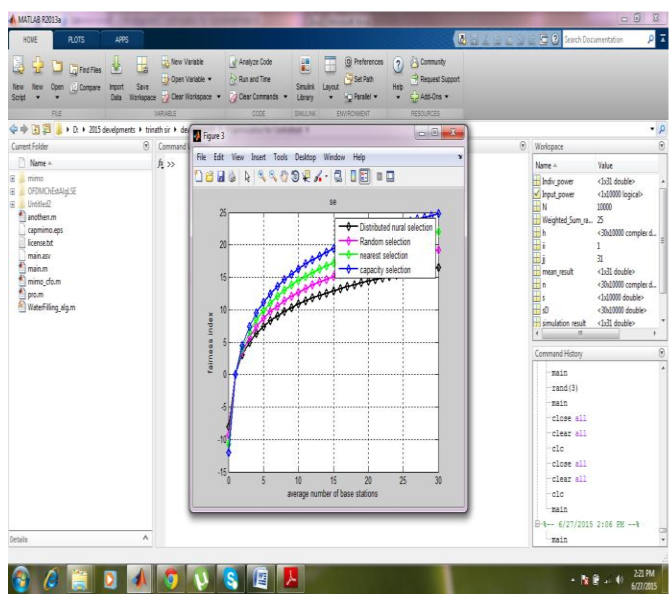
$$F_{MCF}(z) = \sum_{e \in E(G)} u_e z_e$$

IMPLEMENTATION AND EXPERIMENTS OF THE COGNITIVE RADIO NETWORK

In this section, we implement the optimization algorithms on cognitive wireless networks with the functionality of IEEE1900.4. We use the cognitive wireless system of [21] and [22] as the basic wireless network architecture for our implementation. This architecture enables seamless use of the RANs for all of the mobile terminals with vertical handover functionality across different wireless networks. In our experiments, we use this system with the wireless LANs in our laboratory to evaluate our algorithms. The structure of the experimental system, which is implemented with supporting IEEE1900.4 functionality, is shown in Figure 4.2. There may be several ways to implement the proposed algorithms in this cognitive wireless network. For the centralized algorithm described in this Section, the NRM calculates the optimal connections for all of the terminals. To run the centralized optimization algorithm at the NRM, the capacities of each RAN, c_j, and the available connection lists for each terminal, A_i, are collected by the NRM via the RMC and the RE interfaces, respectively. Using the collected information, the NRM runs the rigorous optimization algorithm and obtains the optimal selections of RANs for all of the terminals. This information is transmitted to all of the mobile terminals using their RE interfaces.

According to the notification, each mobile terminal establishes the communication link to the suggested one by the NRM, and the optimal state of thwireless network can be realized. When a part of c_j or A_i changes, the NRM updates the optimum state and notifies each terminal of the updated information, which switches the connection to the updated best BS. During this switching, the communication session on the mobile terminals can be continued by the mobile IP, which is supported by the omeagents (HAs) on the server side. There are several ways to implement the distributed algorithm described in the network. For example, the updates of the neurons can be executed at each RAN, at each BS, or at each mobile terminal.

5, SIMULATION RESULTS



6, CONCLUSION

In this project, we have defined optimization algorithms for heterogeneous cognitive wireless networks. As a typical optimization problem, we introduced load balancing to improve the service quality of the entire wireless networks. To optimize the problem, we proposed two algorithms. For a network that can be managed by a centralized server, we have realized a rigorous optimization algorithm by modeling the problem as a minimum cost-flow problem. For the network that cannot be managed by a centralized server, we applied a distributed algorithm based on the Hopfield–Tank neural network. Further, we have implemented the proposed algorithms on an experimental wireless network, which is a cognitive wireless cloud system. Using the implemented system, we show that the distributed algorithm works correctly using our design of a protocol based on the IEEE1900.4 architecture.

FUTURE SCOPE

We have considered a problem in heterogeneous wireless networks, namely, traffic load balancing, which is a typical optimization problem that seeks to avoid traffic congestion. In order to improve the radio resource usage of the wireless networks, there are various other factors that should be optimized. In this paper, we presented two examples of how to optimize the network. The proposed optimization framework can also be applied to other more complicated optimization problems in wireless networks. As an important remaining issue, we have to clarify which is the better, the centralized, or the decentralized, for some practical network. In the centralized management, we have shown that it is possible to obtain the rigorously optimal state of the network, but the entire context information should be collected into the centralized manager and the decision made by the manager should be distributed to all of the terminals in entire networks. Therefore, the signaling delay may influence the performance. On the other hand, in the decentralized management, although it is not possible to guarantee the optimality of the obtained solution by the algorithm, there is no need to distribute the decision from one point to entire networks. The better approach will be decided on the basis of various factors of the network such as the signaling delay, the network size, and so on. More detailed analysis on the comparison of these two approaches will be shown elsewhere.

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