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Resource allocation in Cognitive radio networks using Weight based synchronization

Chandni, P.Sudha,R.Kokila,

Bharathiyar Institute of Engineering for Women,
Attur(Tk), Salem (Dt), India

Abstract**—**Wireless mesh networks have the potential to deliver Internet broadband access, wireless local areanetwork coverage and network connectivity at low costs. The capacity of a wireless mesh network is improvedby equipping mesh nodes with multi-radios tuned to non-overlapping channels. By letting these nodes utilizethe available channels opportunistically, we increase the utilization of the available bandwidths in the channel space.The essential problem is how to allocate the channels to these multi-radio nodes, especially when they are heterogeneous with diverse transmission types and bandwidths. Most of current work has been based on the objective to achieve maximal total bandwidths. In this paper, we propose a new bipartite-graph based model and design channel allocation algorithms that maximize the minimal channel gain to achieve relative fairness. Our model maps heterogeneous network environment to a weighted graph. We then use augmenting path to update channel allocation status and use canonical form to compare the new status with previous status to achieve better fairness. Evaluations demonstrate that our algorithms improve fairness compared with related algorithms.

Index Terms—Dynamic Spectrum Allocation, Cognitive Radio, Mesh Networks

I. Introduction

Cognitive radios are widely viewed as the disruptive technology that can radically improve both spectrum efficiency and utilization. Cognitive radios are fully programmable wireless devices that can sense their environment and dynamically adapt their transmission waveform, channel access method, spectrum use, and networking protocols as needed for good network and application performance. One of the applications of cognitive radio is more efficient, flexible, and aggressive dynamic spectrum access. The research community has made significant progress in addressing the many research challenges associated with cognitive networks and DSA. However, there is a big gap between individual research results, effectively building blocks, and the large-scale deployment of cognitive networks that dynamically optimize spectrum use. Recent developments such as the FCC TV white space ruling, an example of DSA based on a primary-secondary user model, and LTE-A,

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which relies on flexible spectrum use, offer great opportunities to demonstrate the potential value of cognitive networks and DSA. Failure to act on these opportunities could delay commercial deployment for many years.

This breakout session brought together technology and policy researchers to explore how we can realize the great potential and commercial success of cognitive networks and DSA. Specifically, we tried to identify both long-term research challenges and near term research opportunities.

II. A Cognitive radio usage scenario: Spectrum Sensing based access

Wireless communication systems require spectrum for their operation but interference poses a serious threat if systems in close geographical proximity use the same band simultaneously. This leads to a global spectrum regulation system in which a given spectrum band is exclusively allocated for a certain service licensed to use that band at any given location. But this kind of allocation of the scarce resource results in under-utilization due to unfair distribution among different services. This can clearly be seen from the allocation of the TV spectrum. A larger amount of spectrum is allocated to TV broadcast systems (on the order of 300 - 400 MHZ) even though large chunks of that spectrum remain unused most of the time [2]. On the other hand, the total spectrum currently occupied by or recommended for mobile communications systems is around 230 - 430 Mhz depending on the geographic region [17]. Christo Ananth et al. [4] discussed about creating Obstacles to Screened networks. In today's technological world, millions of individuals are subject to privacy threats. Companies are hired not only to watch what you visit online, but to infiltrate the information and send advertising based on your browsing history. People set up accounts for facebook, enter bank and credit card information to various websites. Those concerned about Internet privacy often cite a number of privacy risks events that can compromise privacy which may be encountered through Internet use. These methods of compromise can range from the gathering of statistics on users, to more malicious acts such as the spreading of spyware and various forms of bugs (software errors) exploitation. However, the rapid transition in cellular networks from limited data mobile telephony to universal broadband mobile services in recent times led to a huge capacity demand that cannot be accommodated by the spectrum resources that are allocated to these systems. One approach of research interest to tackle the aforementioned problem is a cognitive radio scenario where spectrum sensing is employed for dynamic and flexible access. In this approach, the spectral environment is sensed and any unused resource allocated to the primary system is assigned to a secondary system. The other approach to dynamic spectrum access is to allow secondary systems to access spectrum resources that have been allocated to a primary system under restrictions that the secondary usage does not harmfully interfere with the primary service. Three different paradigms of dynamic primary-secondary spectrum access have been discussed and are presented in the following sections.

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III. Synchronization in Cognitive radio networks

Timing synchronization problem has gained a new aspect in cognitive radio and has been developed as one of the most challenging issues in cognitive radio systems. In the interweave cognitive radio approach, timing synchronization is not such a challenge that needs to be addressed as it is in the overlay approach. Nonetheless it would be wise to briefly discuss how white space spectrum access works in this subsection. In interweave cognitive radio systems, the secondary system needs to determines spectrum holes or spectrum white spaces in time, frequency and/or geographic location that left vacant by the primary system. This strategy is based on cognitive radios that can detect the usage of spectrum resources in order to discover spectrum usage opportunities. White spaces can be determined by spectrum sensing [26][27], or in case of rather static spectrum usage of the primary system by means of Geo-location combined with access to a spectrum usage database [28]. In the later case, synchronization between White Space Devices (WSD) and a spectrum usage database might be a point of discussion.

In the cognitive overlay approach, where the secondary uses the same spectrum as the primary system at the same time, the secondary system should know the message and the transmission timing of the primary system in advance. This allows the secondary system to design its own transmitted signal such that interference from the primary system to the secondary receiver can be mitigated. At the same time, the secondary system can cooperate with the primary system by relaying the primary signal; this enables the secondary system to compensate for interference that it causes to the primary receivers. For all this to work properly however, the secondary system must be time-synchronized to the primary system. In the following subsections, white space access and general synchronization aspects of cognitive radio spectrum sharing in interweave and overlay approaches will be discussed.

III. General Synchronization Aspects of Interweave Cognitive Radio Systems

Geo-location database synchronization process aims to ensure the same data content among several participating entities, possibly having different sets of content. TVWS database synchronization can be performed in two ways: Unidirectional synchronization/centralized synchronization and bidirectional database synchronization. The Unidirectional synchronization / centralized synchronization scheme is working only with the authorized government database, i.e., the commission's Consolidated Data Base System (CDBS) and the universal licensing system (ULS). In a unidirectional synchronization, all of the contents from the CDBS/ULS will be placed in other clearinghouse/databases, which also implies any content in the

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clearinghouse/database entities that do not exist in the CDBS/ULS database will be deleted.This is applied only to the registered incumbent devices in the CDBS/ULS. This scheme also is suitable with the hierarchical database within the same database service provider.

Bidirectional database synchronization is suitable for non-registered TVBDs, the contents of which will be merged with all the participating databases. However, the security module should make sure that no unauthorized data will be injected into the database.There are several other factors that need to be taken care of when implementing the database synchronization, i.e., how frequently this synchronization of data will be conducted, speed of implementation, security, performance, and the immediate update of data

In beacon based white space spectrum access, each WSD shall maintain a beacon period start time (BPST). The device shall derive all times for communication with its neighbors based on the current BPST. The device shall adjust its BPST in order to maintain super frame synchronization with its slowest neighbor. A device shall synchronize with such a device before it sends its first beacon. When a device receives a beacon from a neighbor, the device determines the difference between the beacon's actual reception time and the expected reception time. The beacon's actual reception time is an estimate of the time that the start of the beacon preamble arrived at the receiving device's antenna. The expected reception time is determined from the information in the received beacon and the receiving device's BPST. If the difference is positive, then the neighbor is slower. In order to maintain frame synchronization with a slower neighbor, the device shall delay its BPST by the difference, but limited to a maximum adjustment of a specified amount per frame

IV. Synchronization in Overlay Cognitive Radio Systems

The issue of synchronization between the primary and the secondary systems is one of the challenges in cognitive overlay spectrum sharing . There are a number of ways to deal with the time synchronization problem in such systems. One approach would be synchronization of the primary and the secondary symbols at the primary transmitter. In another approach, synchronization of the primary and the secondary waveforms can also be performed at the secondary receiver. These approaches will be discussed in the following sections.

V. Synchronization at the Secondary Transmitter

In this approach the secondary transmitter tap the primary signal and looks for the symbol starting time of the primary symbols. After the secondary transmitter determines the symbol starting time and transmission intervals of the primary transmitter, it synchronizes its transmission to the primary transmitter before sending its aggregate signal. This approach simplifies the synchronization at the secondary receiver as there will only be a single channel and conventional synchronization techniques discussed in the previous sections can be applied. Let xp(t) and xs(t)

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be the primary and the secondary signals respectively at the secondary transmitter. The combined primary-secondary waveform x(t) can be written as:

$$x(t) = xp(t) + xs(t + \tau)$$

where τ is the timing offset between the primary and the secondary symbol transmission. In the presence of AWGN the discrete channel impulse response for this Equation can be given as:

$$h(n) = |xp|\,\delta(n) + |xs|\,\delta(n + D) + w(n)$$

where D is the delay in samples between the primary and the secondary OFDM symbols and w(n) is a AWGN. From the equivalent channel frequency response equation, H(k), shown below we can examine and counteract the effect of the delay in the phase and the amplitude of the aggregate signal.

$$H(k) = |xp| + |xs|\, e\ {-j2\pi Dk}\ N + W(k)$$

where k is the sub-carrier and N is the FFT length. As an example the phase and the magnitude of the channel frequency response at SNR of 15 is shown in Figure 17 below for a delay of 20 samples. Performing the synchronization at the secondary transmitter helps to take computational complexity off the receiver thus enabling simple and less expensive receivers with a better battery life.

VI. Synchronization at the Secondary Receiver

In this approach, synchronization is performed on the waveform as it reaches the secondary receiver. In overlay systems with relaying, the secondary transmitter splits its power to transmit its own message and to relay the primary signal. Hence, the secondary transmitter sends an aggregate of the primary and the secondary signals. Since the primary system is also transmitting, the aggregate signal from the secondary transmitter and the primary signal from the primary transmitter reach the secondary receiver with some timing offset to each other. The secondary receiver estimates the phase response of the multi-path channel and uses it to construct the primary signal. Once the primary signal is constructed, the secondary receiver cancels it from the aggregate signal to find the residual signal.

VII. Conclusion :

In this paper we have analyzed different Synchronization techniques used in the previous techniques as well as different methodology suggested in the future study. We also discuss the merits and some of the findings which will be incorporated to improve the synchronization and improving the signal prediction. Based on our study we will suggest an parameterized protocol which will suggest the synchronization and Bit Error Rate (BER) according to the distance variations.

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