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Modeling Spectrum Sensing and Optimal Time Interval Selection for Cognitive Radio System

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***Abstract*— Cognitive Radio (CR) is a promising technology for next-generation wireless networks in order to efficiently utilize the limited spectrum resources and satisfy the rapidly increasing demand for wireless applications and services. In cognitive radio technology, the wireless system is used to find a vacant band that cognitive radio user can use when its use doesn't interrupts the primary user. During the mobility of secondary user has to move from one primary user system to another primary user system. So the user should check periodically whether the band is still vacant for channel selection and the optimal time interval between two successive checks for spectrum availability, we are using spectrum sensing and geo-location database scheme. We have to maximize the duration of spectrum availability checks while ensuring that the probability of the cognitive radio user disturbs the primary user (PU) should less than a specified threshold. Authenticating the PU signal in order to mitigate PU emulation attacks. Authenticating primary user's signal in CRN integrates link signatures and cryptographic mechanisms.**

***Keywords*— cognitive radio, spectrum sensing, channel selection, Geo-location database, PU emulation attack.**

I. INTRODUCTION

Cognitive Radio (CR) is an enabling technology to give the solution for spectrum scarcity and it will significantly enhance the spectrum utilization of future wireless communications systems. The efficient spectrum management functionalities to occupy idle channels without causing interference with the primary users, and leave these channels when primary user activity is detected. Two schemes to find a vacant band have been considered: a Geo-location-database-based scheme and a spectrum sensing based scheme [4]. In the DB-based scheme, a CR system to finds vacant bands by accessing the database that contains information about the location and the spectrum usage of Primary systems [5]. In the sensing-based scheme, the status of the bands can be found by directly sensing the spectrum [3]. After vacant bands have been found, the CR system can use them. It does not interfere with the PU; it should check periodically to conform that the band that use is still available for its use. In CR environments, the bands that are available to a CR user can change for two reasons: 1) Variation in PU activity over time and 2) change in location by a CR user [5] [6]. We propose a PU authentication system that securely and reliably delivers PU activity information to SUs. Our system does not require any modifications to the legacy system, as mandated by the FCC [7]. Provision of robust sensing information is facilitated by the deployment of a set of "helper" nodes. Helpers are deployed within the area of the secondary network, independent of the location of the PUs, and can be relatively cheap low-power devices.

As an example, Fig. 1 shows a SU sensing the idle spectrum in the presence of an adversary. Assume that a total of 10 channels are available to the legacy system, and that channels (1, 3) and (2, 4, 5) are occupied by two PUs within the range of the SU [8]. In a non-adversarial setting, the SU would have sensed channels (6, 7, 8, 9, 10) as idle. However, in the presence of an adversary emulating PU activity on channels (6, 7, 8), the set of idle channels sensed by the SU is limited to (9, 10).

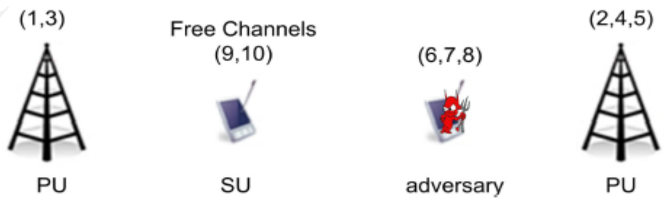

Fig. 1. Primary user emulation attack scenario.

II. COGNITIVE RADIO TECHNOLOGY

Cognitive radio (CR) is a key enabling technology in dynamic spectrum access (DSA). CR Networks (CRNs) can maximize the use of bandwidth resources without changing well- established regulation of spectrum allocation. Secondary users (SUs) can make use of unoccupied licensed spectrum bands opportunistically when the legacy devices or primary users (PUs) are idling. Thus, CRN becomes a compelling Solution to the spectrum scarcity problem. Two main characteristics of cognitive radio has controlled through primary base stations.

A. Cognitive capability

The cognitive capability refers to, sensing of the RF environment, by the Cognitive radio. In sensing of the RF environment the unused part in the spectrum (referred to as empty frequencies) are specified.

Spectrum Sensing: Spectrum sensing implies the data collection from the radio neighborhood not only for the identification of temporally unused slots in the spectrum but also for all other relevant details. These unused slots are called as spectrum holes or white space.

Spectrum allocation: Spectrum allocation based not only on the sensed spectrum parameters but various other functions. The spectrum allocation follows two steps.

Spectrum analysis: The analysis of spectrum parameters and identifying the spectrum holes is carried out in order to determine various parameters that are required to choose a suitable band for transmission.

Spectrum decision: The decision about the selection of a suitable band for transmission is not only depending on the spectrum information acquired by spectrum analysis.

B. *Reconfigurability*

Cognitive Radios that allows the change in the parameters according to the changing radio environment. As mentioned earlier, the Cognitive Radio can adjust its operating parameters for the transmission, without any modifications on the hardware components. Cognitive radio adapt easily to the dynamic radio environment.

III. PROPOSED METHOD

Objective of my paper is to choose the best channel for that used reduce that time interval between the two checks for spectrum availability by implementing a geo-location and spectrum sensing scheme. The initial database system will try to cover all the primary user information. A cognitive radio system finds the vacant band by accessing the database that contains information about the location and the spectrum usage of primary user systems. The cognitive user uses the geo-location database to find nearest primary user. It is maximized to reduce the spectrum handoff. The cognitive radio user needs to know its current position; cognitive radio user utilizes the GPS in the geo-location database. There is a security problem that is primary user emulation attacks in CR networks. PUE attacks are known as a new type of attacks unique to CR networks. In such an attack, the hostile user takes the advantage that the legitimate SU has to evacuate the spectrum band upon the arrival of a PU. An attacker emulates the PU's transmitting signal and misleads the legitimate SU to give up spectrum band. PU signal authentication method based on a network of monitoring nodes which verify the origin of PU signals using received signal strength (RSS) measurements.

A. *Spectrum Sensing and Geo-Location Database*

Wireless link global communication channel (WLGCC) to the CR system. The cognitive radio system send request to the base station is assumed to transmit its service through a reserved database channel. The reserved channel for the new system is called the Global Communication Channel. The cognitive radio system has two methods of determining the status of database in the radio environment: spectrum sensing and geo-location database. After the channel status is acknowledged, assuming that the channel is empty, the cognitive radio device needs to calculate its own power in band and power out of band methods. The wireless link global communication channel enhances the spectrum sharing methods by eliminating the need for a low detection threshold and the hidden node problem. Fig2 wireless link global communication channel transmits its signal through the global communication channel to provide information about the current occupied channels. Second, in the geo-location database method, the wireless link global communication channel can provide a reliable communication link between the CR and the database to eliminate the need for Global Positioning System and the internet to identify the physical location of the CR device.

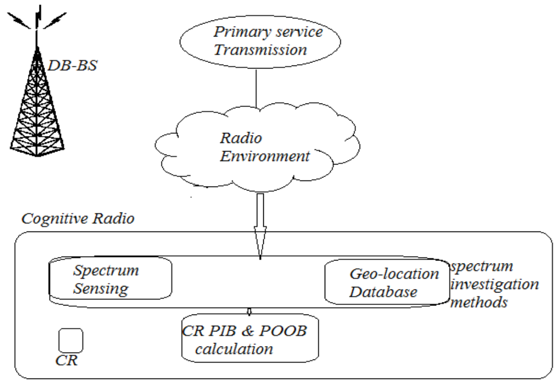

Fig 2: WLGCC

IV. SYSTEM MODEL

We consider a multi-band CR environment. We make the following assumptions.

• The total number of bands is B_T.

• The PUs in each band is distributed randomly and independently and their distribution can be modeled as a homogeneous Poisson Point Process (PPP) whose density is λ_{PU}.

• Each PU has its own no-talk zone, within which CR users should not use the band of the PU. The radius of the no-talk zone is R_{NT}. The band is vacant outside the no-talk zone, so CR users can use it if the CR users are located outside that zone. Given that the PUs in different bands is independent to each other, the number of vacant bands can be modeled by using a Binomial random variable. Moreover, we assume that the no-talk zone of a primary user does not overlap with the no-talk zone of other user.

• The average number of vacant bands is BV. λ_{PU} and BV are related to each other. For a given area A, the area that is covered by the no-talk zone of the user is $\lambda_{PU} \cdot A \cdot \pi \cdot R_{NT}2$. Therefore, if $\eta = BV/BT$, the following equation should be satisfied: $\eta = (A-\lambda_{PU} \cdot A \cdot \pi \cdot R_{NT}2)/A = 1-\lambda_{PU} \cdot \pi \cdot R_{NT}2$

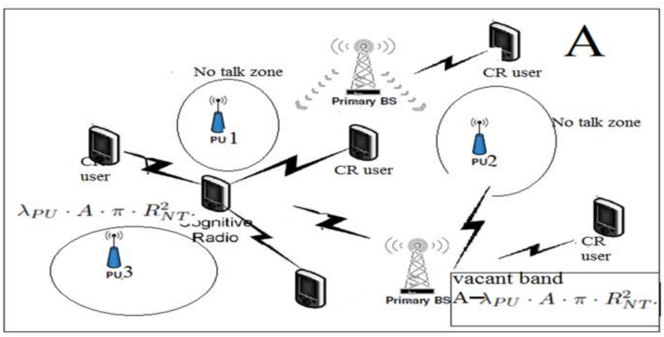

Fig 3: Find vacant band

V. Channel Selection

A cognitive radio user chooses a band such that the time interval between two checks for spectrum availability can be maximized. Therefore, the cognitive radio user chooses a band such that the distance between the cognitive radio user and the nearest primary user is maximized. Channel selection scheme is used spectrum sensing and geo-location databases are used to determine the primary user activity on a channel. The spectrum sensing scheme to provide the different channels in a given region. Geo-location database scheme already knows ahead of time about the spectral opportunity available on a channel over a given time. Therefore this technique can plan ahead for the selection of channel satisfying by the user. The cognitive radio user can find this band, which we denote as ˆ*j*, by using the following equation:

$$J = \underset{j \Sigma J}{\operatorname{argmax}}\; d_i^j$$

Where $d_i{}^{\wedge j}$ is the distance between the cognitive radio user and the *i*-th PU in band *j*, which is the nearest PU to the cognitive radio user in band *j*. J is the set of vacant bands that can be found by using a geo-location database. By using equation the cognitive radio user can choose the vacant band such that the distance between the CR user and the nearest PU is maximized. Given that the distribution of PUs is a homogeneous passion point process, the pdf of $d_i{}^j$, which is the distance between a cognitive radio user and the nearest PU in the selected band *j*, can be found.

VI. Channel Allocation

In Fig 3**,** the CR will not use the free channels unless it receives the WLGCC's signal. The CR-UE will continuously sense the WLGCC's transmitted signal. In case the CR detects the signal, it sends a request to the database for the availability of the free channels. The WLGCC will receive the information from the CR-UE via the GCC and send it to the database. The database finds the free channels from a lookup table and calculates the required transmit power of CR based on its location (in case the GLD method is used). The WLGCC transmits the database information via GCC to the CR-UE. The CR takes the initial decision to operate in the vacant frequency. The CR-UE double check with the CR-BS the information from the database. If the confirmation is positive, the CR system uses the free channel and sets its transmitted power according to the database. In case the CR-UE changes its location, the process starts from the beginning; otherwise, it will keep using the free channels and continue sensing the WLGCC for any further instructions.

A. Cognitive Base Station Registration

Cognitive radio base station registration request to spectrum access opportunity, the database calculate the vacant band frequency and response to the cognitive user. The cognitive radio registration is successful and creates the spectrum access in fig 5 suppose the spectrum band frequency is not vacant in the spectrum access, update the database and then find the near base station. The cognitive radio link setup request to neighborhood base station and response to the link setup.

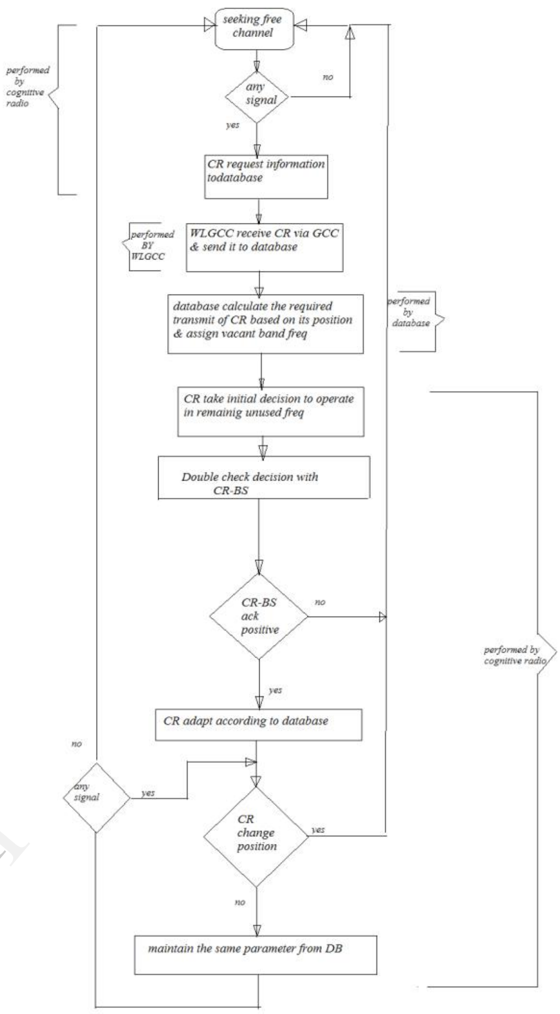

Fig 4: Channel Allocation

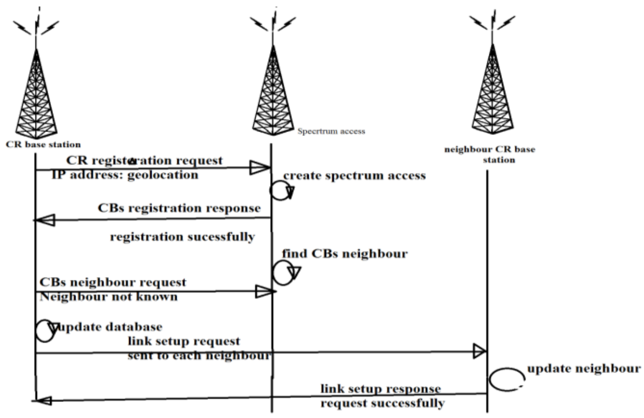

Fig 5: Cognitive base station registration and response

VII. PU Emulation Attack

A PUE attack is a new type of attack unique to CR networks, in which the attackers may modify their radio transmission frequency to mimic a primary signal, thereby misguiding the legitimate SUs to erroneously identify the attackers as a PU.

Detection Approaches for PUE Attacks

1) Energy Detection: Energy detection is simple but widely used approach for spectrum sensing in CR networks. It is also one of the basic approaches for the detection of PUE attacks. By measuring the power level of the received signal at the SU receiver and comparing it with that from the true PUs, the CR network could judge whether the signal comes from an attacker or not.

2) RSS-based Detection: Received Signal Strength based detection approach is discussed in [3], where the authors analyze the PUE attack in the CR network without using any location information. Thus, this detection approach does not need dedicated sensor networks. The PUE attackers are assumed to be distributed randomly around the SUs. The authors present an analysis using Fentons approximation and Walds sequential probability ratio test (WSPRT) to detect PUE attacks.

3) Location Verification: Two location verification schemes are proposed in [2]. They are called Distance Ratio Test (DRT) and Distance Difference Test (DDT), respectively. In both schemes, dedicated cognitive nodes with enhanced functionality are involved for location verification. DRT uses a Received Signal Strength based method, where two dedicated cognitive nodes measure the RSS of the signal source and calculate the ratio of these two RSS to check whether it coincides with their distances to the true PU. Using DDT, the arrival time of the transmitted signal from the source is measured by the two dedicated cognitive nodes. The product of the time difference and the light speed is then compared to the distance difference from the true PU to the two dedicated nodes in order to identify the source.

VIII. Simulation Results

Give five different frequency channels and each primary user is assigned in a particular frequency band. Assign a band in ascending order.

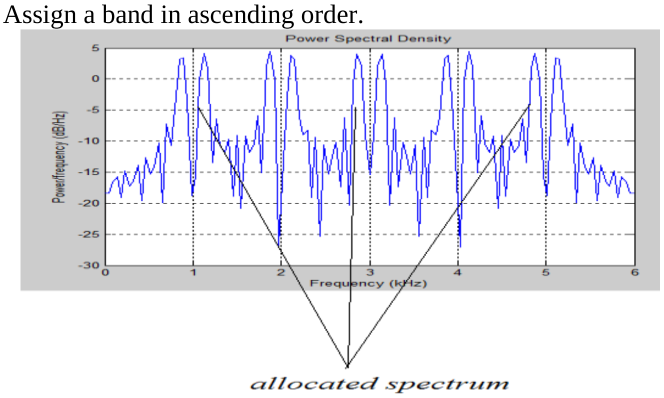

Fig 6: Allocated Spectrum

Secondary user can enter in that area when the primary users are free but now all the primary users are present in that area. So no vacant band frequency is available.

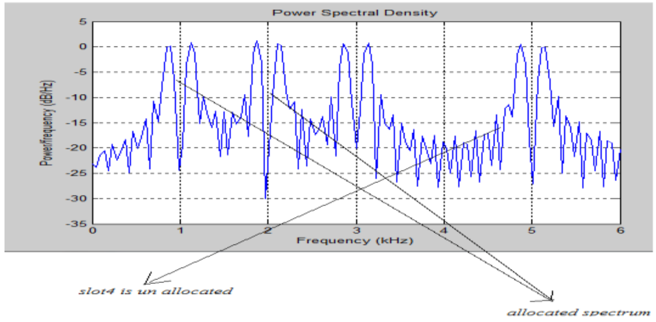

Fig 7: Allocated and Non-Allocated Spectrum

IX. Conclusion

Cognitive radio technology can solve the problem of spectrum underutilization. The availability of bands in the spectrum changes according to the movement of mobile cognitive radio users; in consequence, cognitive radio users have to check the availability of the channel frequently. It will produce system overhead. By using the spectrum sensing and geo-location database method we can solve this problem. We considered channel selection and have to find the optimal time interval between two checks for spectrum availability. We maximized the time interval between two checks for spectrum availability to reduce the overhead of cognitive radio systems. The disturbance produced by the cognitive radio user to the PU should be less than a specified threshold. The spectrum can be checked efficiently with low overhead. Primary user authenticating system based on the deployment of “helper” nodes, fixed within the geographical area of the CRN. These nodes are responsible for authenticating the PU signal using link signatures (cryptography).

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