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# An Effective Energy and Attack Based Spectrum Sensing Method for Cognitive Networks

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Abstract

*Cognitive Radio (CR) is a technology that promises to solve the spectrum shortage problem by allowing secondary users to coexist with primary user without causing any interference to the communication. The spectrum sensing is one of the main challenges encountered by cognitive radio A serious threat to cognitive radio networks that sense the spectrum in a cooperative manner is the transmission of false spectrum sensing data by malicious sensor nodes. The Unlicensed Secondary Users may transmit fake information about the spectrum for its future use. Those Secondary users will be known as the Selfish users. They will degrade the network performance. Here, a method which uses Credit HazardCost (CHC) and Signal activity Pattern Acquisition and Reconstruction System is being proposed to identify the selfish users to improve the network performance.NS2 tool,hasbeen used to evaluate a existing and proposed system performance*

## I. INTRODUCTION

Current data networking technology limits a network's ability to adapt, often resulting in sub-optimal performance. Limited in state, scope and response mechanisms, the network elements (consisting of nodes, protocol layers, policiesand behaviors) are unable to make intelligent adaptations. Communication of network state information is stifled by the layered protocol architecture, making individual elements unaware of the network status experienced by other elements.

Any response that an element may make to network stimuli can only be made inside of its limited scope. The adaptations that are performed are typically reactive, taking place after a problem has occurred. according to the FCC (Federal Communications Commission) recent report on spectrum utilization ,measurement data shows that licensed frequency bands are heavily under-utilized. As a way of making more efficient use of the limited frequency resource, researchers have been studying cognitive radios, devices that can adapt their operating characteristics to the channel condition, as a candidate for secondary spectrum access.

A cognitive radio is a wireless communication device that intelligently utilizes any available side information about the (a) activity, (b) channel conditions, (c) encoding strategies or (d) transmitted data sequences of primary users with which it shares the spectrum. Based on the type of available network side information along with the regulatory constraints, secondary users seek to underlay, overlay, or interweave their signals with those of primary users without significantly impacting these users . In the next section we describe these different cognitive radio paradigms in more detail. The fundamental capacity limits for each of these paradigms are discussed in later sections.

### Cognitive Radio Network Paradigms

There are three main cognitive radio network paradigms: underlay, overlay, and interweave. The underlay paradigm allows secondary users to operate if the interference they cause to primary users is below a given threshold or meets a given bound on primary user performance degradation. In overlay systems the secondary users overhear the transmissions of the primary users, then use this information along with sophisticated signal processing and coding techniques to maintain or improve the performance of primary users, while also obtaining some additional bandwidth for their own communication.

Under ideal conditions, sophisticated encoding and decoding strategies allow both the secondary and primary users to remove all or part of the interference caused by other users. In interweave systems the secondary users detect the absence of primary user signals in space, time, or frequency, and opportunistically communicate during these absences. For all three paradigms, if there are multiple secondary users then these users must share bandwidth amongst themselves as well as with the primary users, subject to their given cognitive paradigm. This gives rise to the medium accesscontrol (MAC) problem among secondary users similar to that which arises amongusers in conventional wireless networks. Given this similarity, MAC protocols thathave been proposed for secondary users within a particular paradigm are often derived from conventional MAC protocols. In addition,multiple secondary users may transmit to a single secondary receiver, as in the uplink of a cellular or satellite system, and one secondary user may transmit to multiple secondary receivers, as in the corresponding downlink. We now describe each of the three cognitive radio paradigms in more detail, including the associated regulatory policy as well as underlying assumptions about what network side information is available, how it is used, and the practicality of obtaining this information. Underlay Paradigm. The underlay paradigm, shown in Figures mandates that concurrent primaryand secondary transmissions may occur only if the interference generated by thesecondary transmitters at the primary receivers is below some acceptable threshold.Rather than determining the exact interference it causes, a secondary user can spread its signal over a very wide bandwidth such that the interference power spectral density is below the noise floor at any primary user location. These spread signals are then despread at each of their intended secondary receivers. This spreading technique is the basis of both spread spectrum and ultrawideband (UWB) communication. Alternatively, the secondary transmitter can be very conservative in its output power to ensure that its signal remains below the prescribed interference threshold.

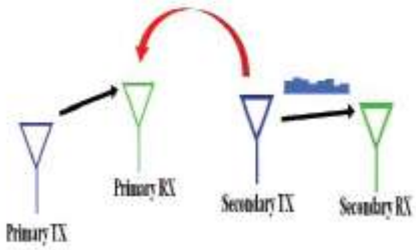

Fig underlay paradigm

In this case, since the interference constraints in underlay systems are typically quite restrictive, this limits the secondary users to short range communications. Both spreading and severe restriction of transmit power avoid exact calculation of secondary user interference at primary receivers, instead using a conservative design whereby the collective interference of all secondary transmissions is small everywhere.

If the secondary user occupies only the null space of the MIMO primary receiver, no interference is caused, and hence this falls within the interweave paradigm discussed below, whereby the primary and secondary users occupy orthogonal spatial dimensions. The underlay paradigm is most common in the licensed spectrum, where the primary users are the licensees, but it can also be used in unlicensed bands to provide different classes of service to different users.

**Overlay Paradigm**

The premise for overlay systems, illustrated in Fig. , is that the secondary transmitter has knowledge of the primary user's transmitted data sequence (also called its and how this sequence is encoded (also called its codebook). Similar ideas apply when there are multiple secondary and primary users. The codebook information could be obtained, for example, if the primary users follow a uniform standard for communication based on a publicized codebook. Alternatively, the primary users could broadcast their codebooks periodically.

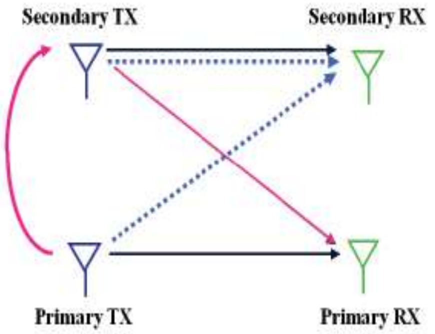

Fig overlay Paradigm

A primary user's data sequence might be obtained by decoding it at the secondary user's receiver or in other ways Knowledge of a primary user's data sequence and/or codebook can be exploited in a variety of ways to either cancel or mitigate the interference seen at the secondary and primary receivers. On the one hand, this information can be used to cancel the interference due to the primary signals at the secondary receiver. Specifically, sophisticated encoding techniques like dirty paper coding (DPC) can be used to precode the secondary user's signal such that the known primary user interference at the secondary receiver is effectively removed. On the other hand, the secondary users can assign part of their power for their own communication and the remainder of the power to assist (relay) the primary transmissions. By careful choice of the power split, the increase in the primary user's signal-to-interference-plus-noise power ratio (SINR) due to the cooperation with secondary users can be exactly offset by the decrease in the primary user's SINR due to the interference caused by the fraction of the secondary user's power assigned to its own communication. If the primary receiver can be modified to decode both its data sequence and all or part of the secondary user's data sequence, then the interference caused by the secondary transmitter to the primary receiver can be partially or completely removed. This guarantees that the primary user's rate either remains unchanged or can be increased, while the secondary user obtains capacity based on the power it allocates for its own transmissions. When there are multiple secondary and primary users then a MAC protocol for each user class and more sophisticated encoding and decoding techniques will be required.

Interweave Paradigm

The interweave paradigm is based on the idea of opportunistic communication, and

was the original motivation for cognitive radio . The idea came about after studies

conducted by the FCC universities ,and industry showed that a major part of the spectrum is not fully utilized most of the time. In other words, there exist temporary space-time-frequency voids, referred to as spectrum holes or white spaces, that are not in constant use in both the licensed and unlicensed bands, as shown in Fig. The spatial spectrum holes may be in a single spatial dimension or, for MIMO devices, in the subset of spatial dimensions not occupied by the primary users (i.e. in the null space of the primary users' receivers) . Spectral holes can be exploited by secondary users to operate in orthogonal dimensions of space, time or frequency relative to the primary user signals. Thus, the utilization of spectrum is improved by opportunistic reuse over the spectrum holes. The interweave technique requires detection of primary (licensed or unlicensed) users in one or more of the space-time frequency dimensions. This detection is quite challenging since primary user activity changes over time and also depends on geographical location

## Fundamental Performance Limits of Wireless Networks

A wireless network consists of a collection of wireless devices communicating over a common wireless channel. The simplest wireless network consists of a single-user (point-to-point) channel. In general, a wireless network contains multiple source nodes, each communicating its information to a set of destination nodes. A wireless network can have a supporting infrastructure (e.g. as in cellular networks), or an ad hoc structure, where nodes self-configure into a network and control is decentralized among the nodes. The typical topologies of multiuser channels (in isolation or within one cell of a cellular system) are multiple access (many transmitters to one receiver) and broadcast (one transmitter to many receivers) channels. These channels correspond, respectively, to the uplink and downlink of a satellite system or one base station in a cellular system. In these networks, communication occurs between a group of nodes transmitting to or

receiving from a single node. In an ad hoc wireless network, each node can serve as a source, destination and/or relay forwarding data for other users. In cognitive radio applications, primary and secondary users accessing the same spectrum form a wireless network. Primary and secondary users have different transmit/ receive constraints due to interference limitations at the primary receivers, as well as possibly different transmit/receive capabilities. In cognitive radio networks the primary users can be cellular or ad hoc, whereas the secondary users are generally ad hoc and fall into the paradigms of underlay, interweave or overlay. Hence, these two types of cognitive radio network users form a two-tier wireless network. Performance limits of wireless networks are thus of direct relevance to the performance limits of cognitive radio networks. In particular, the fundamental capacity limits of ad hoc networks not only dictate how much information can be transmitted by secondary users under a given set of network and interference conditions, but also limitations on the information exchange possible between sensing nodes to collaboratively assess spectral occupancy. In the following section we describe the broad range of performance metrics relevant to wireless networks, including their capacity. We then formally define mutual information and capacity for single-user channels as well as for general wireless networks.

Performance Metrics The fundamental performance limits of a wireless network define their best possible performance relative to one or more specific metrics. Many different metrics can be used to measure performance, such as capacity, throughput, outage, energy consumption, as well as combinations of these and other metrics. Since wireless networks exhibit significant dynamics (user movement, data traffic, channel variations, etc.), these dynamics must be taken into account in the definition of the network performance metrics.

The most common fundamental performance limit for time-invariant communication systems is Shannon capacity - the maximum rate that can be achieved over a channel with asymptotically small probability of error. Shannon's simple yet elegant mathematics coupled with his revolutionary ideas for coding over noisy channels and bounding their fundamental data rate limits via mutual information has inspired generations of theorists and practitioners, and provided significant insights into communication system design. For single-user channels the Shannon capacity is a number, the maximum data rate of the channel, as will be defined mathematically in terms of the channel's maximum mutual information in the next section. For a multiuser (broadcast or multiple access) channel Shannon capacity is a K-dimensional region defining the maximum rates possible for all K users simultaneously. Shannon capacity of wireless single-user and multiuser channels is known in many cases, including static and time-varying single-user, broadcast and multiple access channels with noise, fading, multipath, and/or multiple antennas

Spectrum sensing

Spectrum sensing can be said to be the process of performing measurement on a part of the spectrum and making a decision related to spectrum usage based upon

measured data . Spectrum sensing is a fundamental operational block of the cognitive radio (CR) which consists of spectrum sensing, management, sharing and spectrum mobility. The growing demand for wireless application has put a lot of strain on the usage of available spectrum. In order to address this situation and improve spectrum efficiency.

## II. RELATED WORK

Syed HashimRazaBukhari, SajidSiraj, and Mubashir Husain Rehmani were proposed the Wireless sensor networks (WSNs) can utilize the unlicensed industrial, scientific and medical (ISM) band to communicate the sensed data. The ISM band has been already saturated due to overlaid deployment of WSNs. To solve this problem, WSNs have been powered up by cognitive radio (CR) capability. By using CR capability,WSNs can utilize the spectrum holes opportunistically. The sensor nodes which need large bandwidth to transmit their sensed data from source to destination require some scheme which should be able to provide them a wide band channel when ever required. Channel bonding (CB) is a technique through which multiple contiguous channels can be combined to form a single wide band channel. By using channel bonding (CB) technique, CR based WSN nodes attempt to find and combine contiguous channels to avail larger bandwidth.ZhaoweiQu, Yang XuI, Sixing Yin were proposed a cognitive radio wireless sensor network (CR -WSN), where each sensor node is equipped with cognitive radio. A typical concern in CR-WSN is energy consumption due to resource-constrained nature of sensor nodes. Moreover, additional energy is consumed in a CR-WSN to support CR-exclusive functionality such as spectrum sensing and switching, which could shorten sensor node lifetime. However, some sensor nodes could receive similar signal due to similar channel condition such that they probably have same spectrum sensing results. Consequently, we propose a clustering based scheme for spectrum sensing in CR-WSN, which reduces energy consumption by involving less nodes in spectrum sensing. Smart Grid integrates digital processing, sensor technology, automatic control and communication to the traditional power grid to achieve more efficient electricity distribution and management. Applying wireless sensor networks (WSNs) to Smart Grid can greatly facilitate the real-time information exchange within the power management system, and enable fast adaptation of the system to environmental changes. However, there are many challenges that need to be addressed for applying WSNs to the Smart Grid. One critical issue is how to receive data at the controller's node in a timely manner considering the typically time sensitive environment in Smart Grid and the limited battery power supply in WSNs. Based on data classification, proposes a data transmission strategy in WSNs. FawazAlassery was proposed Smart Wireless Sensor Networks, it is imperative to utilize the most power efficient techniques to prolong the lifetime of a sensor node. Backpressure based scheduling has a remarkable performance for smart WSNs, and it has been discussed extensively in literatures. However, considering the energy efficiency of Backpressure scheduling algorithms for recourse-constrained smart WSNs is still need to be studied in order to design smart WSNs with minimum energy consumption.G.LakshmiPhani, K.VenkatSayeesh, K.Vinod Kumar, G.Rama Murthy were proposed the Recent advancements in wireless communications enabled the development of small and cheap nodes capable of sensing, communication and computation. These nodes in a network co-ordinate to perform distributed sensing of environmental phenomenon in various fields such as health, military, home. Research on energy sensitive routing in static WSN has led to the development of many routing protocols that ensure max life time of network

## III. SYSTEM DESCRIPTION

Consider a cognitive radio system with one secondary link andone primary link. Suppose that there are $M$ channels that are shared between the primary user (PU) and the SU. At a given time instant,one of the $M$ channels is allocated to the SU. Assume that thesecondary transmission is slotted via periodic sensing, where eachframe consists of a sensing slot of duration $\tau s$and a transmission slotof duration $T$. At the beginning of each transmission slot, the SU maychoose to transmit data on the current channel, stay on the currentchannel without transmitting, or switch to another channel. Unlikethe secondary transmission, the primary transmission is assumed tobe continuous, and it follows an on–off traffic model [9], where theprobability of the primary transmission being on (off) is the same foreach channel.

When energy detection is used, the energy consumption due to sensingis determined by the length of the sensing time. Therefore, using$\tau$ min$s$ as the sensing duration minimizes the energy cost of the SUdue to spectrum sensing. However, such a $\tau$ min$s$ is not necessarilythe optimal in terms of minimizing the total energy cost of the SU,which is incurred from spectrum sensing, spectrum handoff, and datatransmission. This is because increasing the sensing time may result inmore accurate sensing results and smaller probability of switching toa channel that is falsely detected as idle, which, in turn, leads to lowerenergy consumption, given the throughput and delay constraints of thesecondary transmission. Therefore, there exists an optimal $\tau s$when thetotal energy consumption of the SU is concerned.

After obtaining information of the availability of all channelsthrough sensing, the SU will make a decision prior to transmissionon whether to switch to another vacant channel or stay on the currentchannel.We assume that, if the SU switches to another channel, it must perform transmission for a time duration of $T$ until the next sensingslot arrives. However, if it stays on the current channel, it may choose

to perform data transmission for a time duration of $T$ or simply refrainfrom transmitting until the next sensing slot arrives. We assume thatthe delay due to spectrum handoff is small enough that it is negligible.

In addition, when the SU waits on the current channel with power off,we assume that the energy consumption during this transmission slotis negligible.

Fig 1: Energy-efficient spectrum sensing and access mechanism for the SU to transmit a packet of data.

A flowchart of the SU's spectrum access process is given in Fig. 1.Such a switch-wait model is designed considering the tradeoff betweenenergy savings and the performance of the secondary transmission interms of throughput and delay. For example, when the current channelis sensed as idle, the SU should stay on the current channel andcontinue data transmission because there is no benefit to the SU interms of both energy savings and throughput increment by switchingto another channel. Similarly, when all$M$ channels are sensed as busy,the SU should wait on the current channel and power off for a durationof $T$ seconds, because attempting to switch or transmit on any of thechannels will simply increase power consumption without improvingthe throughput and delay of the secondary transmission. In the casewhere the current channel is sensed as busy and there is at least oneother channel that is sensed as idle, the SU needs to decide whether towait on the current channel with power off to save energy at the costof an increased delay and a reduced throughput, or to spend energy toswitch to a vacant channel such that the secondary link transmissioncan continue. In such a case, we assume that the SU waits on thecurrent channel and stops transmission with a probability of $Ps$, orswitches to another vacant channel with a probability of $1 - Ps$. Thedesign of the spectrum access strategy tominimize the total energy costrequires determining $Ps$, which relies on the accuracy of the sensingresults and, therefore, is an implicit function of $\tau s$.

## IV. SIMULATION RESULTS AND DISCUSSIONS

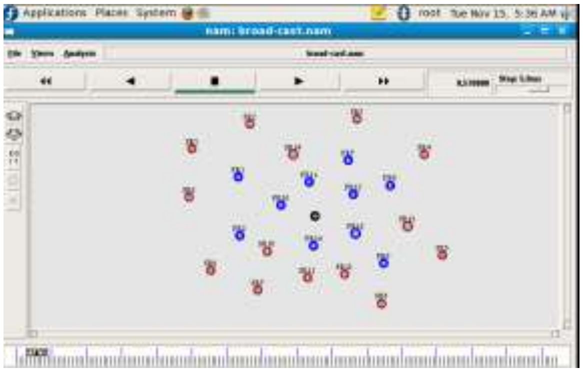

Fig 5: Node creation

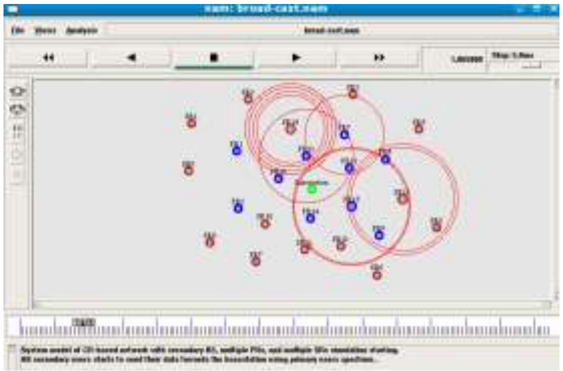

Fig 6:All secondary users sending data to primary users

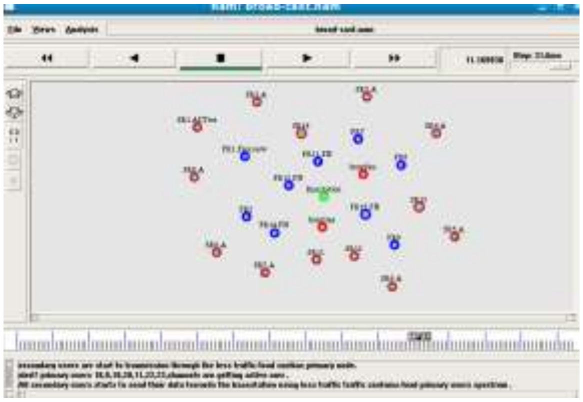

Fig 7: Secondary users sending data to base station

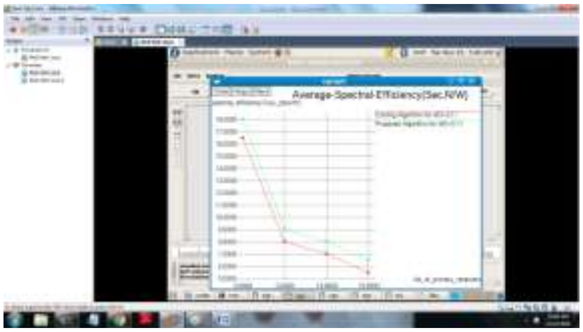

Fig 8: Average spectral efficiency

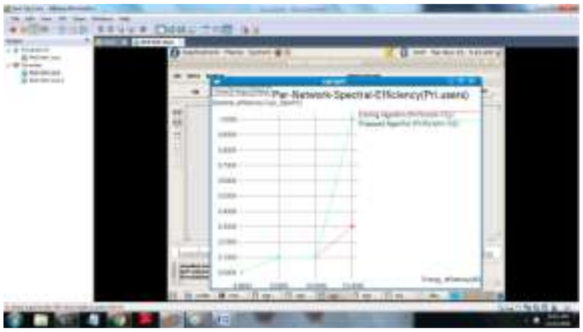

Fig 9: Pre-Network spectral efficiency

## V. CONCLUSIONS

In this paper, a spectrum sensing and access mechanism with spectrumhandoff has been proposed. The proposed mechanism has jointlyconsidered the sensing/throughput tradeoff in terms of the duration ofsensing time $\tau_s$, as well as the wait/switch tradeoff in terms of theprobability of channel switching $1 - P_s$. An optimization problem hasbeen formulated and has been efficiently solved such that $\tau_s$and $P_s$are jointly optimized to minimize the energy consumption of the SU in transmitting a packet of data while, at the same time, satisfyingmultiple constraints on the sensing reliability and performance of thesecondary transmission in terms of throughput and delay. Simulationresults showed the optimality of the proposed mechanism and the benefitof performing spectrum handoff where more stringent throughputand delay constraints on the secondary transmission can be satisfiedwhile providing the minimum energy cost.

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