Maximizing Throughput of Cognitive Radio Networks through Secondary User Power Consumption

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Abstract- A cognitive radio outline requires the QoS of the primary coil winding substance an exploiter maintained while the spectrum allocated to the primary exploiter is used by the Secondary exploiter. The primary user in such cognitive radio system may use a queue to computer memory package boat during transmittance. In such a system the stableness of the queue has to be ensured. This sharing of available spectrum may happen through any of the styles of process such as articulation interweave-underlay meant fashion or only-interweave mode. In reefer interweave-underlay mode, secondary coil user transmits when primary user is absent and transmits adaptively when the primary user is present tense. In the Spiff Interweave-underlay mode, the role of the intercession restraint on the secondary user transmit business leader is of vital importance. Hence in this project, we use the technique of adaptive packet public exposure in meter to increment achievable packet throughput along with interference constraint on secondary user transmit power. We present the method playacting acting and provide the pretense results and analyze them for different duct conditions.

1. INTRODUCTION

With the advent of communication technology, spectrum has become a very precious resource. In the available spectrum range, most of the useful spectrum is already allocated for various services. Still there are spectrum holes which exist in temporal, spectral and spatial domains. Proper and Judicious use of these idle spectral holes may prove to be valuable and also improve utility. Cognitive radio technology is a solution which enables a Secondary User (SU) or Cognitive User to adaptively modify its transmission parameters to transmit opportunistically for maximum spectrum sharing with Primary User (PU) without degrading the performance of PU transmission. Hence there is an increased interest among the research community to study and refine the same. For instance, optimal power allocation to maximize instantaneous transmission ratio of SU under different interference constraints was studied by researchers the idea of time spreading of symbol on orthogonal frequency division multiplexing (OFDM) sub-channel to keep received signal to interference plus noise ratio (SINR) on each sub-channel constant despite interference from primary user (PU) transmission in adjacent bands. In authors focus on maximizing transmission bit rate of SU under constraints imposed by PU, however transmission of busty nature is not considered where if not decoded correctly the whole packet is lost. The authors in studied packet based PU system in which PU stores packet in a queue and proposed power allocation for achieving maximum stable SU throughput. Stable throughput with multiple SUs in an ad-hoc network is analyzed. In, the authors studied on SU and multiple PUs transmitting packets to a common destination and compare stable throughput for conventional multi-access channel (MAC) scheme and relaying scheme. However in author considers only-interweave mode of transmission in which SU transmit only when PU is sensed absent. Authors have proposed joint interweave-underlay scheme for OFDM based SU where SU transmits when PU is absent as well as present by controlling SUs’ transmit power. In, authors have proposed maximum sum-outage capacity of OFDM based cognitive radio under PU queue stability constraint where authors proposed the idea of total power constraint. Authors considered both only...
interweave mode and joint interweave-underlay mode of transmission in where authors proposed the idea of time spreading to maximize packet throughput of CR. In [14] the authors have considered the queue stability constraint for a system with queues for both PU and SU and have compared the throughput achieved for the joint interweave-underlay and only-interweave modes. They conclude their work by observing that only-interweave mode is not optimal in all channel conditions. They have also proposed time spreading by spreading packets over time and recombining them at SU receiver to increase SINR and provided results by analyzing the throughput achieved for varying degrees of time spreading. In our work we propose a total power constraint on the secondary user for various cases. Under these power constraints we provide simulation results for the average packet throughput of SU and analyze the same.

2. SYSTEM OVERVIEW

Primary transmitter-receiver and a pair of secondary transmitter-receiver. At PU transmitter, arriving packets are stored in a queue of infinite length. Arrival process of packets at PU is stationary with average $\lambda_p$ packets per slot. The departure process is independent of arrival process. PU transmits with power $P_p$. We assume that SU always has packet to transmit. In the same band SU transmit with power $P_s$ as that of PU. A channel model is shown in figure. The channel coefficient between PU transmitters to PU receiver is denoted by $h_{pp}$. The channel coefficient between SU transmitters to SU receiver is $h_{ss}$. The interference channel coefficient between PU receiver and SU transmitter is denoted by $h_{sp}$. The channel coefficient between SU receivers and PU transmitter is $h_{ps}$. It is assumed that all channels are Rayleigh faded with variance $p_p$, $s_s$, $s_p$, and $p_s$, respectively. The degree of interference from SU to PU and PU to SU depends on channel gains of interference channel $h_{sp}$ and $h_{ps}$. It is also assumed that all channel parameters are known at SUs.

3. PACKET THROUGHPUT ANALYSIS

This section gives expressions for PU and SU packet throughput and power constraints.

A. Primary User Throughput

We consider a general case where SU transmits with probability $t$ when PU is present and with probability $s$ when PU is absent. At PU, packet is correctly decoded if signal to interference plus noise ratio is above a threshold value $\beta_p$. Then average packet throughput of PU can be given as,

$$\mu_p = t \times Pr\left(\frac{P_p |h_{pp}|^2}{\sigma_N^2 + P_s |h_{sp}|^2} > \beta_p\right) + (1-t) \times Pr\left(\frac{P_p |h_{pp}|^2}{\sigma_N^2} > \beta_p\right).$$

After simplification as given in [9],

$$\mu_p = t \cdot \exp\left(-\frac{\beta_p \sigma_N^2}{P_p \sigma_{pp}^2}\right) \left(1 + \frac{\beta_p \sigma_{pp}^2 P_s}{\sigma_N^2 \sigma_{pp}^2} \right)^{-1} + (1-t) \cdot \exp\left(-\frac{\beta_p \sigma_N^2}{P_p \sigma_{pp}^2}\right),$$

PU achieves maximum packet throughput when SU does not transmit. it is denoted by $\mu_{pmax}$ and given as,

$$\mu_{pmax} = \exp\left(-\frac{\beta_p \sigma_N^2}{P_p \sigma_{pp}^2}\right).$$

Loyne’s’ theorem says that, if packet arrival process and packet departure process are stationary and independent then primary queue remains stable if packet departure rate is greater than packet arrival rate. Hence,

$$\mu_p > \lambda_p.$$  

Therefore SU should choose its transmission power such that queue stability of primary user is maintained at all times. The queue utilization factor ($\eta$) of PU depends on PU packet arrival rate and primary user packet departure rate and is given as,

$$\eta = \frac{\lambda_p}{\mu_p}.$$  

PU queue is empty with probability $(1- \eta)$ and occupied with probability $\eta$. Substituting value of $p$ and simplifying we get,

$$P_s < \left(\frac{\mu_{pmax}}{\lambda_p} - 1\right) \frac{P_s \sigma_{pp}^2}{\beta_p \sigma_{sp}^2}.$$  

This serves as interference constraint on SU transmit power and is given by,
Therefore primary queue remains stable as long as interference caused by SU to PU remains below threshold $I_{th}$. Therefore, for $P_s < I_{th}$

$$I_{th} = \left( \frac{\lambda_p}{\mu_{max}} - 1 \right) \frac{P_p \sigma_{pp}^2}{P_p \sigma_{pp}^2}$$

(7)

After simplification we get,

$$\mu_{s(t,s)} = \eta_{th} \cdot \exp \left( \frac{-\beta_0 \sigma_{N}^2}{\beta_0 \sigma_{N}^2} \right) \times (1 + \frac{\beta_0 P_p \sigma_{pp}^2}{P_p \sigma_{pp}^2})^{-1} \quad (13)$$

where,

$$\eta_{th} = \frac{\lambda_p}{\mu_{th}}$$

and

$$\mu_{th} = \exp \left( \frac{-\beta_0 \sigma_{N}^2}{\beta_0 \sigma_{N}^2} \right) \left( 1 + \frac{\beta_0 P_p \sigma_{pp}^2}{P_p \sigma_{pp}^2} \right)^{-1}$$

**B. Secondary User Throughput**

At SU receiver, a packet is correctly decoded if the received SINR is above a threshold $\beta_s$. Therefore for transmission probabilities $s$ and $t$, the average packet throughput of SU can be given as,

$$\mu_s = \eta \cdot \exp \left( \frac{-\beta_s \sigma_N^2}{\beta_s \sigma_N^2} \right) \times (1 + \frac{\beta_s P_p \sigma_{pp}^2}{P_p \sigma_{pp}^2})^{-1} \quad (8)$$

else,

$$\mu_s = \exp \left( \frac{-\beta_s \sigma_N^2}{\beta_s \sigma_N^2} \right) \times (1 + \frac{\beta_s I_{th} \sigma_N^2}{P_p \sigma_{pp}^2})^{-1} \quad (9)$$

After simplification we get,

$$\mu_{s(t,s)} = \eta \cdot \exp \left( \frac{-\beta_s \sigma_N^2}{P_s \sigma_{pp}^2} \right) \times (1 + \frac{\beta_s P_p \sigma_{pp}^2}{P_p \sigma_{pp}^2})^{-1} \quad (10)$$

Therefore, if $P_s < I_{th}$,

$$\mu_{s(t,s)} = \eta \cdot \exp \left( \frac{-\beta_0 \sigma_N^2}{\beta_0 \sigma_N^2} \right) \times (1 + \frac{\beta_0 P_p \sigma_{pp}^2}{P_p \sigma_{pp}^2})^{-1} \quad (11)$$

and if, $P_s > I_{th}$,

$$\mu_{s(t,s)} = \eta \cdot \exp \left( \frac{-\beta_s \sigma_N^2}{P_s \sigma_{pp}^2} \right) \times (1 + \frac{\beta_s P_p \sigma_{pp}^2}{P_p \sigma_{pp}^2})^{-1} \quad (12)$$

**4. SYSTEM ARCHITECTURE:**

![System Architecture Diagram]
5. DATA FLOW DIAGRAM:

6. MODULES

6.1 POWER ALLOCATION:

Power allocation in OFDM based CRN system have used the adaptive sub-carrier form non-English is not only Channel State Selective information but also the sensing results of SU and interference demarcation of Atomic number 94 s. Here a striation of SU is divided into several sub bank lines, each sub epithelial duct corresponds to a licensed band of one Atomic number 94 system. As interference limit of each PU introduces the sub epithelial duct transmit Rex Restraint for SU, the baron parceling in OFDM based CRN must satisfy the aggregate transmit office constraint and the sub duct transmit ability constraint. The transmit tycoon in each sub channel is comprised of the big businessman allocated to the subcarriers interior the sub channel and the side lobe force fullness of the subcarriers in the other sub good sense of channel . In this method acting playacting, in the mightiness allocation trouble, if the effect of side lobe is ignored, then there is a sufficient safety band between any two neighboring sub ducts. In rescript to maximize the capability and to provide optimal mogul allocation by satisfying both join and sub channel transmit power constraints, iterative piddle -pick algorithm has been used by ignoring the side lobe. Another method is to decouple the sub channel power constraints degree by phase angle by considering the side lobe. The power allocation problem can be classified advertisement into two categories in conventional OFDM-based system arrangement. The first one is to optimize the power allocation across the subcarriers such that the sum pace substance yard is maximized with a given sum transmit power constraint.

6.2 MUTUAL INTERFERENCE:

Interference in OFDM aims at enabling public access to these spectral ranges without sacrificing the transmission quality of the actual license owners. Unfortunately, using OFDM transition in a spectrum pooling organization of rules has some drawback. There is a fundamental interaction between the licensed system and the OFDM based rental systems due to the non-orthogonal opposition of their respectfulness transmitting signals. The source describes the interaction mathematically which provides quantitative evaluation of the mutual intervention that leads to an SNR loss in both systems. However, this interference can be mitigated by windowing the OFDM signal in the sentence orbit or by the adaptive deactivation of adjacent subcarriers providing flexible guard circle between licensed and rental system. It is obvious that both approaches ritual killing bandwidth of the rental system. A quantitative comparison of both approaches is given as a patronage -off between interference reduction and throughput in the rental system. A potential rental system (RS) needs to be highly flexible with respect to the spectral pattern of the transmitted signal. Here, the typesetter's case of an FDMA/TDMA-based licensed system (LS) is confide red. Thus, spectral ranges that are accessed by licensed users (Lutetium) have to be spared transmission power originating from the RUs. OFDM modulation is a campaigner for such a system as it is possible to leave a set of subcarriers unused, which will provide a flexible spectral shape that will fill the spectral gaps without interfering with the Lutetium. This interference is caused by the side lobe of the OFDM signal. .It is possible to reduce the mutual interference of both systems and increasing the throughput of RS can be done by using raised cosine windowing. By using windowing technique number of transmissions could be increased in a system.
6.3 HANDOVER IN LTE SYSTEMS:

A game theoretic solution for channel selection and power allocation was proposed in cognitive radio receiver networks. The author enforced the cooperation among nodes in an effort to reduce the overall energy ingestion in the network. For designing the power ascendancy, the author considered both the case in which no contagion power constraints are imposed and the level best infection power is limited. An iterative aspect algorithmic program for channel scheduling and power allocation has been implemented, which converges to a pure strategy Nash equilibrium solution, i.e., a deterministic choice of channels and the transmission system baron for all substance abuser. To rigging the problem, the author proposed a game theoretic formulation, in which the adaptive channel allocation and power mastery problem is modeled as a potential game. Decisions are based on their perceived service program associated with each possible action the channel selection. Two scenarios (power controller with and without maximum transmission power limitation) are considered, their utilities in a cooperative fashion. The radios’ which is related to the transmission power and to and the effect of various maximum power stratum on the scheme performance is investigated. By using this method, both channel allocation and power control can independently improve the system performance, in parliamentary procedure to achieve a significant amplification for the joint algorithm.

7. FLOW CHART FOR OFDM:

![Flow Chart for OFDM](chart.png)
8. GRAPH:

HANOVER vs SPEED:

NO OF PACKETS LOST DURING HANOVER:
THROUGHPUT vs VEHICLE SPEED:

![Graph of Throughput vs Vehicle Speed](image1)

THROUGHPUT vs PACKETSIZE:

![Graph of Throughput vs Packet Size](image2)
9. CONCLUSION:

The conventional centralized power allocation method involves a server that must have knowledge about global information of the network, which controls all the nodes. So by using the distributed power allocation scheme, it involves a pricing method that determines the utilization of spectrum based on the power level of each secondary user. Meanwhile, the interference between one primary user and one secondary user as well as the interference between two secondary users is reduced by allocation of power based in distributed manner. This scheme provides maximum throughput and node power could be measured for all secondary users in cognitive network. In cognitive radio network, the number of secondary users per channel could be increased in order to reduce interference and avoiding channel wastage within a threshold limit, without affecting the primary users.

10. REFERENCES:

- Y. Xing, C. Mathur, M. Haleem, R. Chandramouli, and K. P. Subbalakshmi, “Dynamic spectrum access with qos and interference temperature constraints,”

- “OMNeT++: A discrete event simulation environment for communication networks.”


