DYNAMIC SPECTRUM SHARING IN WIRELESS COMMUNICATION

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ABSTRACT

Wireless technology is proliferating rapidly and the vision of pervasive wireless computing and Communications offers the promise of many societal and individual benefits. While consumer devices such as cell phones and laptops receive a lot of attention, the impact of wireless technology is much broader. This explosion of wireless applications creates an ever-increasing demand for more radio spectrum, but the radio spectrum has a fixed range that is not much larger and this limited range of the spectrum is major problem in the wireless networks. Spectrum sharing is one method which gives the solution of this problem by shared the limited band of spectrum between the different users. This increases the spectral efficiency of the wireless networks .Dynamic spectrum access is one method of spectrum sharing in which spectrum should be shared by two users i.e. licensed and unlicensed user. The request of unlicensed would be blocked if the spectrum should occupied by the licensees. In this paper we simulated the dynamic spectrum access approach by using hierarchical access model. We also analyzed the blocking probability of secondary users(unlicensed).Blocking should be reduced by applying queueing process and based on queuing model i.e. Erlang model we analyzed the delay probability waiting time waiting probability for secondary user.

KEYWORDS: *Dynamic Spectrum Access, Opportunistic Spectrum Access, Primary user, Secondary user, Spectrum sensing. Blocking probability.*

I. INTRODUCTION

The utilization of the radio spectrum band is given by some national regulatory bodies. In the U.S., the main authorities for radio spectrum regulation are the Federal Communications Commission (FCC).The FCC's spectrum policy gives the actual spectrum usage measurements [1] According to spectrum policy radio spectrum divided into many frequency bands, and licenses for the often exclusive usage of these bands are provided to the service operators Depending on the type of radio service that is then provided by the licensees, frequency bands are often idle in many areas, and inefficiently used. In this condition radio sources are not fully utilized, the alternative way for proper utilization of radio spectrum is Dynamic spectrum access or cognitive radio (CR). Standing for the opposite of the current static spectrum management policy, the term dynamic spectrum access has broad connotations that encompass various approaches to spectrum reform. Dynamic spectrum access strategies can be broadly categorized under three models as shown in figure1.
In the first type of DSA, spectrum bands are licensed to [2] services for exclusive use. Two approaches have been proposed under this model: Spectrum property rights & Dynamic spectrum allocation. The first approach allows licensees to sell and trade spectrum and to freely choose technology. The aim of second approach is to improve spectrum efficiency through dynamic spectrum assignment by exploiting the spatial and temporal traffic statistics of different services. Open sharing model employs open sharing among peer users as the basis for managing a spectral region.

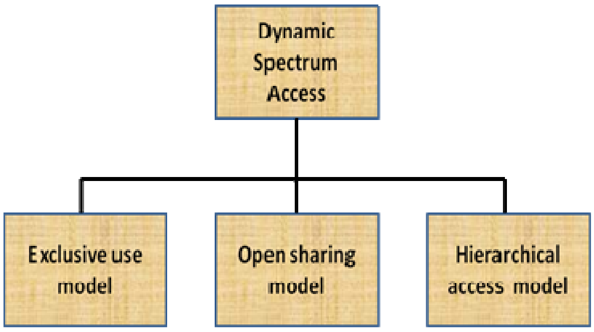


Figure1 Types of Dynamic Spectrum access

Third type of DSA adopts a hierarchical access structure with primary and secondary users. The basic idea is to open licensed spectrum [2] to secondary users while limiting the interference perceived by primary users (licensees). Two approaches to spectrum sharing between primary and secondary users have been considered: Spectrum underlay and spectrum overlay. The underlay approach imposes severe constraints on the transmission power of secondary users so that they operate below the noise floor of primary users. Spectrum overlay comes under the term spectrum pooling and then investigated by the Arpanet Generation (XG)[3] program under the term opportunistic spectrum access. Differing from spectrum underlay, this approach does not necessarily impose severe restrictions on the transmission power of secondary users, but rather on when and where they may transmit. Section 2 contains a brief description of the work done in the related field. Section 3 explained about hierarchical access of DSA, Section 4 describes the erlang model .Result and conclusion is given in section 5.

II. RELATED WORK

In recent years, several papers have analyzed problems pertaining to spectrum sensing and dynamic spectrum access. Reference [2] provided an overview of major technical and regulatory issues in OSA. Spectrum opportunity tracking is done and operating characteristics of spectrum opportunity detector is simulated. In reference [4] the authors examines the technical and operational environments that radios exist within and how cognitive technology may improve the efficiency and effectiveness of their communications.

In reference [5] the authors proposed scheduling schemes such as rate and interference alleviation based scheduling exploiting channel variation across the xG user and delay, interference based scheduling exploiting packet delay along with Quality of Service (QoS) provisioning for multiple xG users escalating the capacity, attaining fairness among the xG users and minimizing interference to PUs. Based on the user requirements, the data rate, bandwidth of the transmission, acceptable error rate, the transmission mode, delay bound can be determined. Then, according to the decision rule, the set of suitable spectrum bands can be preferred. In [6], spectrum decision rules are presented, which are focused on fairness and communication cost. However, the method assumes that all channels have comparable throughput capacity. In order to consider the primary user activity, the number of spectrum handoff, which happens in a specific spectrum band, is used for spectrum decision [7].

III. HIERARCHICAL ACCESS MODEL

This model adopts a hierarchical access structure with primary and secondary users. The basic idea is to open licensed spectrum to secondary users while limiting the interference perceived by primary users (licensees)[2]. Two approaches to spectrum sharing between primary and secondary users have been considered: Spectrum underlay and spectrum overlay. The underlay approach imposes severe constraints on the Transmission power of secondary users so that they operate below the noise floor of primary users. By spreading transmitted signals over a wide frequency band (UWB), secondary users can potentially achieve short-range high data rate with extremely low transmission power. Based on a worst-case assumption that primary users transmit all the time, this approach does not rely detection and exploitation of spectrum white space. Hierarchical model is the most compatible with the current

spectrum management policies and legacy wireless systems. Furthermore, the underlay and overlay approaches can be employed simultaneously to further improve spectrum efficiency.
In this model spectrum sharing is done between two users by a method i.e. spectrum sensing. The spectrum sensing is applied for the detection of the idle space in the spectrum bandwidth .idle space is also known as spectrum hole through which the secondary user's transmission should takes place. Three techniques are employed for spectrum sensing, these are

1. Matched Filter Detection
2. Energy Detection
3. Cyclostationary detection

1. Matched Filter Detection

If the structure of a primary signal is known, the optical detector in stationary Gaussian noise is a matched filter followed by a threshold test. White the main advantage of the in time filter is that it requires less time to achieve high processing gain due to coherency. However with more primary bands being opened for opportunistic access, the implementation cost and complexity associated with this approach will increase prohibitively since a cognitive radio will need dedicated circuitry to achieve synchrony with each type of primary license as required for coherent detection. The matched filter is a linear filter and given as

$$y[n] = \sum_{k-\infty}^{\infty} h[n-k]x[k] \qquad (1)$$

2. Energy Detection

It is a simple alternative for the detection of a primary signal. an energy detector simply measures the energy received on a primary band during an observation interval and declare a white space if the measured energy is less than a properly set threshold. In this paper energy detection method is adopted because it has no require about the prior information of the signal where in other two methods the prior information of the signal should be needed. The energy detection is the test of the following hypotheses:

Ho:Y[n] =W[n] signal absent (2)

H_1:Y[n]=X[n]+W[n]signal present (3)

n = 1, ...,N; where N is the observation window Where X[n] is the sample of the target signal with power σ^2_s The noise sample W[n] is assumed to be additive white Gauss (AWGN) with zero mean and variance $\sigma^2_{w.}$ The decision statistic for energy detector is:

$$T = \sum_{n=1}^{N}(Y[n])^2 \qquad (4)$$

The equation 4 gives the value of the energy of the signal. In the energy detection method if the users must exist in the spectrum then it have some energy level according to its frequency signal which has been found out by a simple energy equation given by equation 5 and it has same value found by the equation 4.

$$Es = \int_{-\infty}^{\infty}|x(t)|^2 \, dt \qquad (5)$$

If the energy of the signal from equation 4 and 5 should not be same then either the users are not exist in the spectrum or it may be an undesired signal or noise signal. The energy spectrum for these method is shown in figure 2, In this figure 10 users should occupied the spectrum, all users should transmitted the signal and having some energy level. The energy level have same amplitude in different frequency allocation, the peak value shows the maximum energy level of the signal for the particular frequency signal.

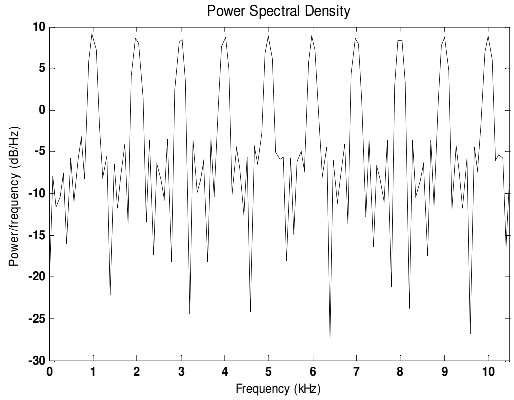


Figure 2 Energy spectrum detection

3. Cyclostationary detection

This approach uses the property of periodicity of the modulated signal. it uses a spectral correlation function to analyze the periodicity of the modulated signal.

IV. ERLANG MODEL

In the paper, we use erlang models also known as queuing models based on queuing theory. The queuing theory is the mathematical theory of waiting lines[8].More generally, queuing theory is concerned with the mathematical modeling and analysis of system that provide service to random demands. The queuing models represent the stochastic nature of the demands by specifying the variability in the arrival process and in the service process.

In these paper we assume that arrival process is Poisson arrival process with arrival rate λ and its distributed function is *Fx(t)* i.e. $Fx(t)=1-e^{-\lambda t}$ for all $t\geq 0$

In spectrum overlay approach of DSA there may be two users PU and SU. If the spectrum is occupied by its PU then requests of the secondary users should be blocked and the blocking probability is given by

$$P_B = \frac{\frac{A^M}{M!}}{\sum_{k=0}^{M} \frac{A^k}{k!}} \qquad (6)$$

Where M is number of primary users, A is offered load in erlangs with arrival rate λ. Now we assumed that the blocked SU will wait in a queue as long as necessary spectrum portion become available, at this time our model is erlang delay model and the delay probability should be P_d,

$$P_d = \frac{MP_B}{M-A(1-P_B)} \qquad (7)$$

The average waiting time W of the secondary user is given as

$$W = P_d \frac{\tau}{M(1-\rho)} \qquad (8)$$

τ is the average service time and ρ is server utilization

The waiting probability is given as

$$P_w = P_d e^{-(1-\rho)s\mu t} \qquad (9)$$

V. RESULT

Our result contains two parts in the first part we simulated the dynamic spectrum sharing technique that is overlay approach of the hierarchical access model and in the second part we simulate the probabilities and waiting time.

We have simulated spectrum overlay approach for primary users and secondary users in which the spectrum should be shared between these two user as shown in figure 3 .In this figure there may be different part i.e. Fig 3(a) shows spectrum with primary users, in this figure all the primary users would access the spectrum or in other word all the seven primary users should transmitted the signal so their energy level is high. These energy levels are shown by the high peaks in the different frequency allocation i.e. high peaks at the frequencies 1000.2000 ……….. 7000 respectively. In these case the whole spectrum should be used by primary users so there may be no space for the secondary user, it means secondary could not access the spectrum now, if spectrum is free from any PU then it may be possible that SU would be access the spectrum.

Fig3 (b) shows that in the spectrum there may be only 4 users which should access the spectrum now. These are at the frequencies 1000, 2000, 3000 and 4000, in other frequency users are not present. The high peaks are only at the four frequencies and in other frequencies there may be no high peaks. The SU should be entered in the spectrum at the frequencies where energy level is very low or below the decision level of the energy detector. These frequencies of the spectrum are referred as spectrum holes.

In the figure 3(c) the first secondary user is now in the place of fifth primary user at the frequency of 5 KHz, so the peak level is high in this frequency which shows that the secondary user should be as a fifth PU in the spectrum and it would be access the spectrum now. In the spectrum there may be two other spectrum holes are existing in the frequencies 6 and 7 KHz, it means we should entered two more SU in these spectrum holes. It can be done in the next figure 3(d) where the second SU will be in the position of sixth primary users.

In the figure 3(a) if all the primary user should access the spectrum then the secondary user's requests should be blocked and these can be given by a probability known as blocking probability discussed below.Our result contains two parts in the first part we have simulated the dynamic spectrum sharing technique that is overlay approach of the hierarchical access model and in the second part we simulate the probabilities and waiting time.

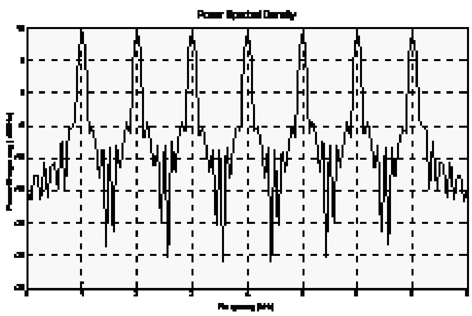


Figure 3(a)

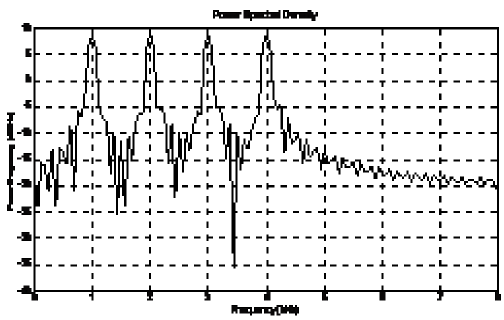


Figure 3(b)

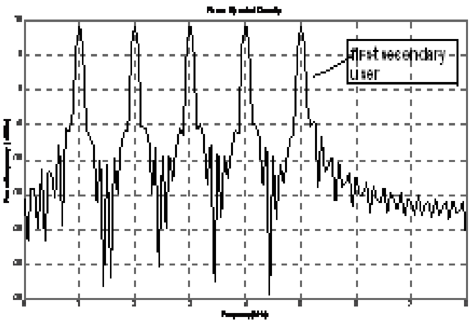


Figure 3(c)

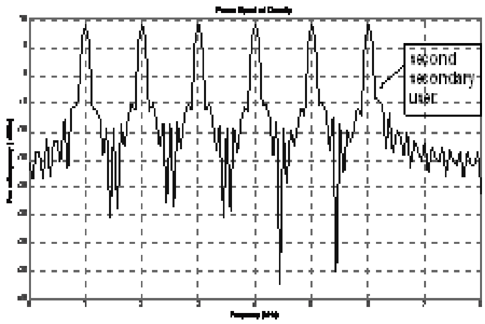


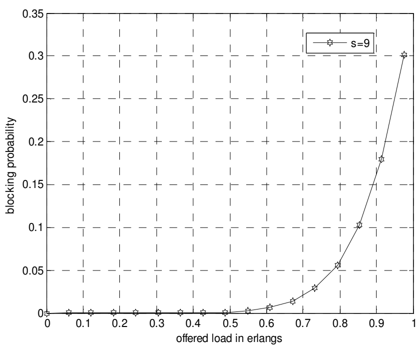
Figure 3(d)

Figure 3 simulated spectrum of hierarchical access model(spectrum overlay appproach)

As shown above if spectrum is occupied by its all primary users then there may be no space in the band for the SU in other word the secondary user's request should be blocked and this can be given by blocking probability**.** In this section of result the Blocking probability is given by the figure 4(a). Which shows the blocking for variable arrival rate with $\underline{\lambda s}$ in the spectrum.

Blocking should be reduced by buffering the SU request which should be done by the queuing. In this mechanism the secondary would be waiting in a queue this increases the probability of SU for accessing the spectrum in place of blockage. Delay probability shows this thing whose value is greater than blocking probability (shown in figure 4(b)).

The waiting time and waiting probability of secondary user when arrival rate is variable is shown in figure 4(c) and 4(d).



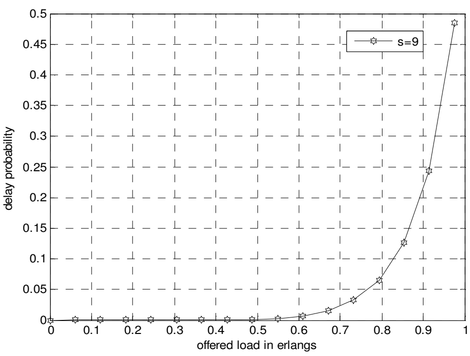
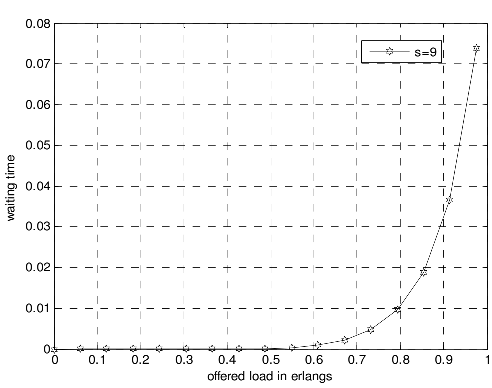


Figure4(a,b) Simulated output of blocking probability & delay Probability for variable λs



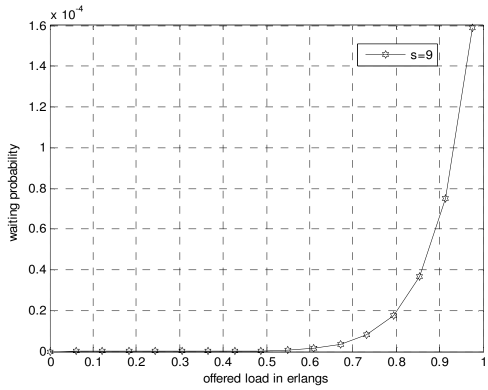


Figure4(c,d) Simulated output of waiting time & waiting probability for variable λs

Now secondary user arrival rate should be constant and the average service time is varied then blocking probability, delay probability, waiting time and waiting probability should be changed shown by figure 5(a,b,c and d)

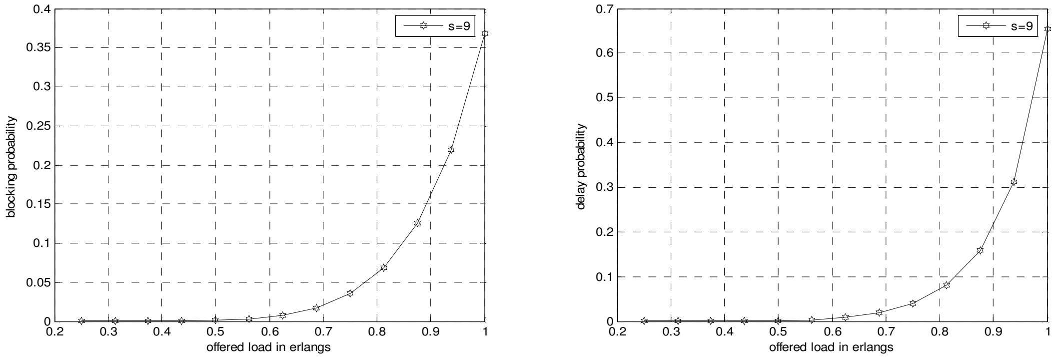


Figure5(a,b) Simulated output of blocking probability & delay probability for constant λs

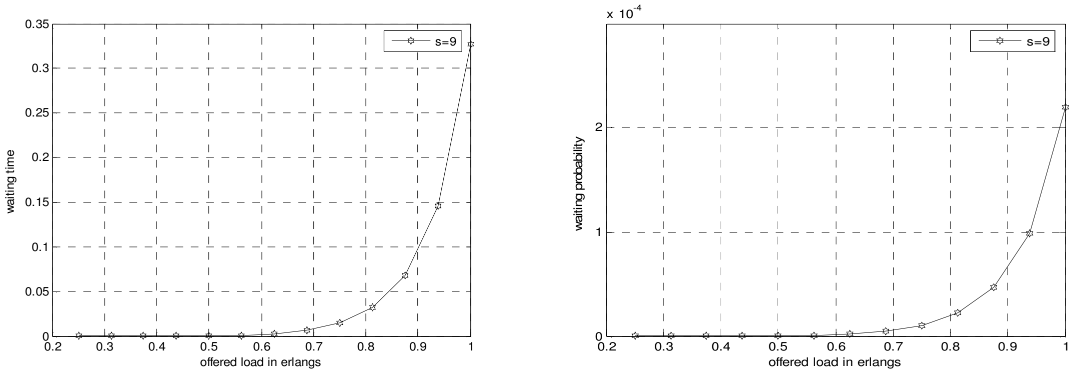


Figure5(c,d) Simulated output of waiting time & waiting probability for constant λs

In this project we observed that all the parameters blocking probability, delay probability waiting time and waiting probability should be increased in case of constant arrival rate compare to variable rate. In both the cases delay should have greater value than blocking. Now the parameters values are shown by the table given below-

Table 1 Different parameters values for variable arrival rate

Traffic load	Blocking probability	Delay probability	Waiting time(Sec.)	Waiting probability
0.97	0.30	0.48	0.073	0
0.85	0.1	0.12	0.018	0.00015
0.73	0.028	0.032	0.004	0.000036
0.67	0.014	0.015	0.0022	0.000003
0.48	0.0009	0.001	0.00014	0
0.4	0	0	0	0

Table 2 Different parameters values for constant arrival rate

Traffic load	Blocking probability	Delay probability	Waiting time(Sec.)	Waiting probability
0.99	0.36	0.64	0.31	0.0002
0.87	0.13	0.15	0.06	0.000047
0.75	0.035	0.04	0.014	0.00001
0.68	0.017	0.019	0.0062	0.0000047
0.56	0.003	0.003	0.0009	0.0000007
0.4	0	0	0	0

VI. CONCLUSION

In this paper the spectrum sharing technique has been simulated .This technique give the solution of little spectrum sharing problem and by using this technique the spectrum should be fully utilized .The spectrum sharing technique is a dynamic spectrum access spectrum overlay approach. In this approach the spectrum should be shared between primary (licensed user) and secondary users (unlicensed user) . When this technique is simulated than if all the primary users are present in the spectrum than secondary could not be access the spectrum. If any PU should not be present than some spectrum portion would be idle. This idle portion is used in DSA by giving this spectrum portion to secondary user for accessing the particular frequency band. The idle frequency band has been found out by energy detection technique of spectrum sensing. In energy detection if the PU exist than its energy level is high and low when PU should not exist in the spectrum.If secondary users request should be blocked than it would be given by blocking probability. The blocking should be reduced by applying queuing mechanism for the secondary user, in this mechanism in place of blocking the request of SU finite queue should be provided for secondary user. This improved the occurrence of SU in the given spectrum. As the number of PU increases the probability would be reduced and also its waiting time in the queue is reduced. For the two different conditions i.e. variable and constant arrival rate when all the probabilities have been evaluated then their values has been changed according to the two different cases. All the parameters have higher value in the second case compare to the first case.

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