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Review on Cognitive Radio Network

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Abstract-As the increased demands of wireless channel, there is the need for the proper utilization of the spectrum which leads us to the new technique called cognitive radio technologies. Static spectrum allocation need to merge with a technique where it can be share for the proper utilization of the spectrum. Higher capacity requirement is of great need. As long as the technology is been evolving the requirement of more capacity is also increasing. This paper gives an overview on different work done for increasing capacity over the years.

I. INTRODUCTION

Cognitive radio technology is the apparent in the current years, which can provide much faster and more promising reliable wireless communication services by utilizing existing wireless spectrum more efficiently and systematically. The users need to know the important difference between the dynamic SS and static SS. In static SS fixed amount of spectrum has been allocated to the particular users for all the time which latterly are called licensed users whereas the dynamic spectrum allocation approaches to the utilizing spectrum in more dynamic way where the users has been classified as PUs which are also known as licensed users and the other are the SUs which opportunistically utilizes the vacant spaces in the spectrum [1]. As seen in fig.1 most of time spectrum has been wasted because it can't be accessed all the time. Spectrum allocation result into higher capacity which is the most required factor of any communication system. Depending on the vacant spaces in the spectrum as shown in fig. 2 spectrum allocation can be done in different way. With growing demand of the increasing population providing higher channel capacity is of great concern. Before going into detail about the work done on capacity for cognitive lets first have a look on different types of spectrum allocation.

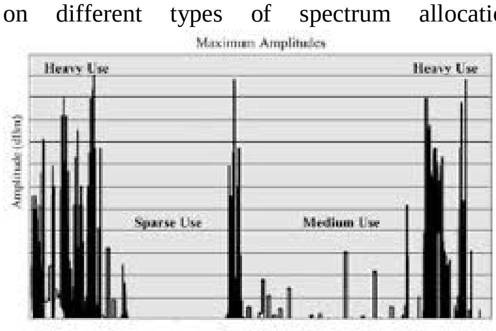

Fig 1 Spectrum Allocation

2. TYPES OF SPECTRUM ALLOCATION

2.1. *Centralized and Distributed spectrum allocation*

This type has been categorized according the infrastructures that has been used [2]. Centralized spectrum allocation is the one where the controlled unit is central one which monitors the available spectrum and assign that to the different SUs. Distributed spectrum allocation is the one in which each SU has its own intelligent unit which scan the available holes in the spectrum.

2.2.*Cooperative and non-cooperative spectrum allocation*

This type has been categorized according to the no. of users and the way they use the spectrum [2]. Cooperative allocation is named after the cooperation of the SUs among themselves for the proper utilization of the spectrum. These users in the game theory are called the players.

Non-cooperative where users are being selfish and does not cooperate with the other game players for the proper utilization of the spectrum.

2.3.*Overlay spectrum allocation and underlay spectrum allocation*

This is categorized according to the spectrum has been accessed. In overlay where after knowing the non-activity of the PU, SU utilizes the complete spectrum. Underlay in which after sensing the presence of the PU it lower down its transmitting power below a threshold value which should not create interference to the PU [3].

2.4.*Interweave Spectrum allocation*

One more common type is the Interweave, where SUs and PU simultaneously use the spectrum but at different powers which should not create interference to each other [3].

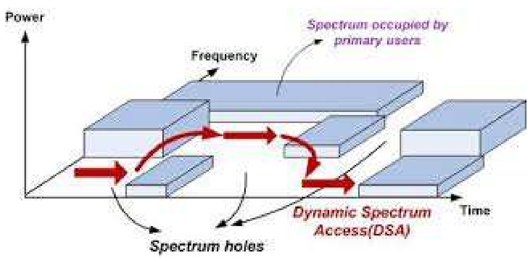

Fig 2vacant spaces in spectrum

3. SPECTRUM SENSING

The necessity of the cognitive radio is to sense the spectrum holes [1] i.e. the secondary user should be able to determine the spectrum holes and detect the existence of the primary user based upon signal received by secondary user. In [3], spectrum sensing techniques are subdivided in to local Spectrum sensing and cooperative spectrum sensing. These techniques are classified as

3.1. *Local spectrum sensing*

Spectrum sensing permits the secondary user to access the spectrum holes. In spectrum environment, both primary user and secondary users co-exist. When the primary transmitter is sending the data to primary receiver in a licensed spectrum then the secondary users attempt to utilize the spectrum. The secondary user transmitter will have to achieve the spectrum sensing to check that the primary user is in secondary user range or not so that interference from secondary user can be controlled [3].

The matched filter detector, energy detection method, feature detection are the various types of the local spectrum sensing technique.

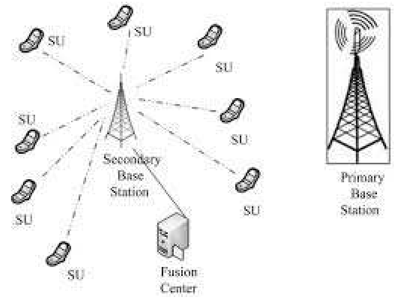

Fig 3 System Model for Cognitive Radio Networks

3.2. *Matched filter detector*

This technique required that secondary user should have a prior knowledge of primary user. The received signal is correlate with primary signal to determine the existence of primary signal [2], [4].

3.3.*Energy detection method*

Energy detection become widely used technique since it is easy to implement and sense primary user signal. Energy detection is done through sampling, once enough samples has been obtained they are compared with predetermined threshold. Sensing PU signal can be defined as a binary hypothesis model [5], [1].

$$x(n) = w(n) \qquad : H_0$$

$$x(n) = w(n) + s(n) \qquad : H_1$$

- x(n) is signal received by the SU.
- w(n) is additive white Gaussian noise.
- s(n) is the from the primary user.
- H_0 is the null hypothesis describing primary user absence in the channel.
- H_1Indicates the presence of the some primary user signal.

4. SYSTEM MODEL

The system always work in a way where there are one or more SUs along with PU could be present. There is a primary transmitter, primary receiver and on the other hand there is secondary transmitter along with secondary receiver. Fig. 3 showing basic configuration of the system model which has been assumed in this scenario. SU opportunistically use the channel of the PU after sensing PU in the channel. If the PU is active in the channel the SU can use the channel as long as it does not affect the reception quality of the primary receiver that is been termed as interference temperature. To obtain this some constraints has been imposed on the transmission power of the secondary transmitter but recent researches alsoshown some of the constrained has been applied on the receiver as well. These constraints applied for the different capacities which are defined below.

5. TYPE OF CAPACITY

5.1.*Ergodic Capacity*: Ergodic capacity has been defined as the maximum achievable rate which can be obtained for long term [6], [7].

5.2.*Outage capacity*: Outage capacity has been defined as the maximum capacity that can be obtained with some outage probability [6], [7].

5.3.*Minimum Rate Capacity*: This is combination of ergodic capacity as well as outage capacity where the minimum achievable rate which can be obtained for longer duration of time.

6. LITERARURE REVIEW

In [5] authors has provided closed form capacity formula subject to the average received power constraint (ARPC) and peak received power constraint (PRPC) for the different fading channels i.e 1) AWGN channel, 2) log-normal shadowing , 3) Rayleigh Fading, 4) Nakagami Fading with perfect channel side information. Their system model includes a secondary transmitter and primary as well as secondary receivers. Their result has been shown that significant capacity gain for the varying channels can be obtained. Furthermore the channel capacity for Rayleigh channel is higher than AWGN channel for all the different values of average SNR.In [6] authors has been investigated the effect on capacity for Rayleigh Fading channel with imperfect feedback. They have obtained the closed form expression for ergodic capacity with tifr policy and outage capacity subject to ARPC at the primary receiver. Their numerical results has been shown that the ergodic capacity decreased with increased value of channel estimated error variance as compared to the system which has perfect channel state information. Whereas outage probability has been increased with the increasing value of channel state estimation error. However they have conclude that with higher transmission power, higher rate of ergodic capacity can be obtained.In [7] they have estimated the ergodic capacity and outage capacity along with power allocation policy of the Rayleigh Fading Channel with perfect channel state information. In particular they obtained the capacity gains subject to joint ARPC and PRPC. They have taken the system with point to point fading channel. Their numerical results show that as long as average received power is restricted, peak received power does not obtain any significant effect on the ergodic capacity, on the other hand because of the restriction imposed on peak received power outage capacity suffered a great loss.In [8] author has calculated the outage capacity and tifr capacity of SS by employing a novel receiver and frame structure which is combination of sensing time and data transmission time under the different combination of ATPC, AIPC and PIPC. In the subsection the authors first calculated the outage capacity imposed by the ATPC and average interference power followed by Tifr capacity. Second they have calculated the outage capacity with the average and PIPC followed by tifr capacity. Third they have calculated the outage capacity and tifr capacity subject to ATPC, AIPC and PIPC with a high target detection probability last they have calculated the outage capacity and tifr capacity subject to average and PIPC with high target detection probability. Simulation results has shown that the proposed schemes improve the outage capacity and tifr capacity as compared to conventional one.In [9] authors has driven the optimal power allocation strategies for maximizing the ergodic capacity and outage capacity of the SU subject to average and PTPCs with the proposed PU's outage constraint with the perfect CSI at the SU transmitter. In the subsection the authors has first derive the ergodic capacity with PU outage constraint firstly with ATPC and then with PTPC. Next they have derive the outage capacity with PU outage constraint first with the ATPC and then with PTPC. The simulation results has shown that the proposed optimal power allocation strategy produce higher ergodic/outage capacity with PU outage constraint as compared to the conventional one where Interference temperature is taken into consideration.In [10] authors have propose the scenario in utilizing the spectrum sensing information of the PU's activity at the SU's base station for the efficient allocation of transmission time and power of the SU subject to ARPC at the PU and PTPC at the SU. With the help of the spectrum sensing information received by the secondary receiver which is being fed to the secondary's base station is utilized to come to know that which secondary link is good for the access of the channel. The authors has obtain the optimal power and time allocation policy for the broadcast channel for the different scenario. First they have taken the two secondary receivers which are available with perfect channel state information and then larger number of secondary receivers has been taken. Their numerical results has illustrated the performance of the proposed broadcast system. Its shows the prominent increase in the ergodic capacity of the proposed cognitive radio broadcast channel.

7. CONCLUSION

In the past few years, with the advancement in the technology and tremendous increase in the wireless applications required a wide range of spectrum but today the wireless networks are characterized by the fixed spectrum assignment policy which leads to the under-utilization of spectrum so this increase the problem of spectrum scarcity. To solve the spectrum scarcity problem, cognitive radio has developed which allows the unlicensed secondary user to opportuntically access the unused part of the spectrum in such a way that it does not create interference to the licensed primary users. Spectrum sensing, spectrum sharing, spectrum management and spectrum mobility are the fundamental functions of the cognitive radio. Various techniques of spectrum sensing i.e. local spectrum sensing and cooperative spectrum sensing and various types of spectrum sharing i.e. spectrum underlay and spectrum overlay has been discussed.

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