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AN OVERVIEW TO COGNITIVE RADIO SPECTRUM SHARING

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ABSTRACT : Today we deal with growing demands of wireless broadband access, which further goes on increasing. Problem of under utilization of licensed spectrum motivates us to find out different techniques to improve the efficiency of spectrum usages. Here in this paper we discuss an overview through different shades of spectrum sharing. Which deals with cognitive radio meant to provide a better technique to fulfill the utilization of radio frequency spectrum? How primary and secondary user i.e. licensed and unlicensed allocates the spectrum without degrading its own performance. Self organizing networks (SON) are essential for complicated cellular networks. Using this technology we are able to organize and optimize energy, expenditure and performance.
Keywords: CR- Cognitive Radio, SON- Self organizing networks, MANET, WSN- Wireless sensor network, HWN- Hybrid wireless network, etc.

I. Introduction

Technology changes the way of life which is more comfortable in different aspects. Mobile communication eases the way of communication which got dominant over us. The demands of mobile communication are on high peaks. Mobile network is a wireless network distributed over land areas called as cells. Spectrum is a signal which is represented in different domain such as time, frequency, space, geography, etc. spectrum sharing consists of several techniques some administrative, technical and market based. Demands of spectrum are increasing day by day and frequency bands are becoming more congested specially in high populated areas.

To overcome these problems cognitive radio spectrum sharing recently studied to alleviate the problem of under utilization of licensed spectrum. Cognitive radio is the also defined as software radio. Using this system of cognitive radio spectrum can be shared between primary and secondary user. The primary user performance should not be degrading by the opportunistic behavior of the secondary user, thus we use the dynamic spectrum sharing mechanism.

The number of wireless users is increasing day by day at a rate faster than service providers are increasing to obtain new spectrum resources. The high price of new spectrum costs more, thus providers need to employ new techniques in order to maximize their efficiency. Spectrum sharing technologies can provide great promise, but we need additional research and development efforts to move these technologies into mainstream use.

II. Proposed Techniques

FUNDAMENTAL WIRELESS TECHNIQUES

1. Cellular Wireless Networks-

Cellular network is nothing but the mobile networks distributed over a wide geographical area. This network distributed in cells (Hexagonal-shape). [1] Each cell uses a different set of frequencies from neighboring cell to avoid interference. By joining these cells provide radio coverage over land areas. This technique provides more capacity than single large transmitter, use less power and cover large area.

2. Wireless Ad-Hoc Networks-

WANET is usually of decentralized manner. This does not rely on a pre existing infrastructure, such as routers or access points. Here each node participates in routing by forwarding data for other nodes. So the determination of which nodes forward data is made dynamically on the basis of network connectivity. In

addition to the classic routing, ad hoc networks can use flooding for forwarding data. An ad hoc network typically refers to any set of networks where all devices have equal status on a network and are free to associate with any other ad hoc network device in link range. [1] Ad hoc network often refers to a mode of operation of IEEE 802.11 wireless networks.

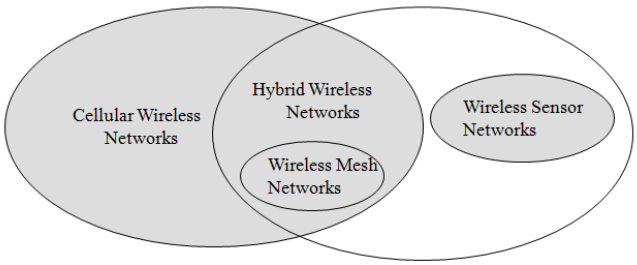

Fig.1 Basic Wireless Techniques

3. Wireless Sensor Networks-

Sensors deployed in a specific geographical area to cater application of communication. This technology is nothing but the wireless sensor networks special category. [3] A sensor network is a collection of a large number of sensor nodes that are deployed in a particular region. Mobility of nodes are not needed in all cases in wireless sensor networks. The size of the network is much larger than that in a typical ad hoc wireless network.

4. Wireless Mesh Networks-

A wireless mesh network (WMN) is a communications network made up of radio nodes organized in a mesh topology. It is also a form of wireless ad hoc network. Wireless mesh networks often consist of mesh clients, mesh routers and gateways.

5. Hybrid Wireless Networks-

HWN are multi-hop cellular networks (MCNs) allow the transmission through the base stations or multi-hop of mobile nodes. Integrated cellular ad hoc relay (iCAR) is a system that combines conventional cellular technology with Ad hoc Relay Station (ARS) technology. In this system cellular stations will relay or reroute calls from the congested cell to an adjacent one that is not congested.

COGNITIVE RADIO

CR is a programmable software radio has software platform for wireless radio transceiver. Radio receiver in the software radio operates at multiple frequency bands by using multiple transmission protocols. It is an extension of software radio. It changes transmission parameters and intelligently adapt wireless environment.

CR technology is being used to provide a method of using the spectrum more efficiently, spectrum sensing is key to this application. [1] The ability of Cognitive Radio systems to access spare sections of the radio spectrum, and to keep monitoring the spectrum to ensure that the Cognitive Radio system does not cause any undue interference relies totally on the spectrum sensing elements of the system.

SPECTRUM HOLE

A spectrum hole is a space available between bands of frequencies assigned to a primary user, but at a particular time and specific geographic location, the band is not being utilized by that user. So to cater the

spectrum efficiently without losing any frequency. We get the dynamic spectrum access which is unutilized optimally.

Gray spaces: These are partially occupied by interferers as well as noise. Spectrum bands which are partially engaged by low power interfaces. [5]

Black spaces: The contents of which are completely full due to the combined presence of communication and interfering signals plus noise. Spectrum bands which are partially engaged by local high power interferers. [5]

White Spaces: The spectrum bands which are not occupied by anyone. They are free of any interferer and noise used to provide efficient bandwidth allocation to the secondary user.

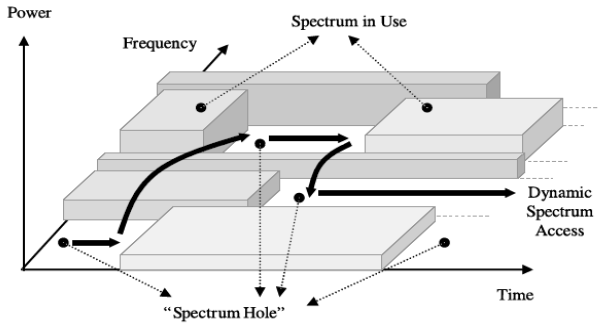

Fig.2 Spectrum Hole [5]

SPECTRUM SHARING TECHNIQUES

Spectrum sharing can be more complex. It involves multiple dimensions. Such that, it is possible to share frequencies in the same geographical area but not at the same time. It also requires geolocation database, spectrum sensing techniques. Spectrum can be shared in several discrete dimensions- frequency, time and geography. The simplest means of spectrum sharing is the operation of systems in the same frequency band but in different geographical areas. [2] These geographical areas could be defined as different markets or defined by geographic exclusion zones. Spectrum sharing techniques are derived as follows -

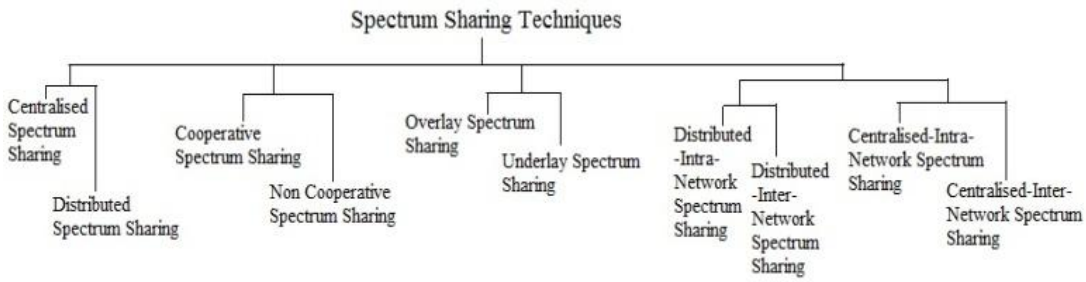

Fig.3 Spectrum Sharing Techniques

1. Centralized Spectrum Sharing:

Centralized optimization exponentially grows with the size of network. A centralized operation controls the spectrum allocation and access procedures. Each operation in the cognitive radio network forwards the measurements of the spectrum allocation to the centralized entity. Using these measurements, the centralized operation constructs the spectrum allocation map. Spectrum set up data for all CR units in the entire network. The centralized system is not scalable.

2. Distributed Spectrum Sharing:

The problem is solved locally using the local data available to each single CR unit. The distributed spectrum sharing is used where the construction of an infrastructure is not necessary. In this case there is no presence of the centralized entity, each and every node is responsible for the spectrum allocation and access is based on local policies performed by each node separately.

The second classification for spectrum sharing techniques in cognitive radio networks is based on the access behavior.

1. Cooperative Spectrum Sharing:

CR unit estimates its interference to other units. It is also known as the collaborative spectrum sharing. It relates with the node's communication on other nodes, in this case the interference measurements of each and every node shared among the other nodes. All the centralized spectrum sharing solutions are considered as the cooperative spectrum sharing. The common technique used in this scheme is to form cluster and share the interference information locally.

2. Non-Cooperative Spectrum Sharing:

Opposite to the cooperative spectrum sharing, only a single node is considered in this technique. It is also called as the non collaborative spectrum sharing; it considers only the node at hand. The nodes will not share the measurements to the other nodes, so it is referred as the selfish solution. By using this method, spectrum utilization can be reduced. Since interference to other CR units is not considered, non-cooperative solutions may result in reduced spectrum utilization.

Both cooperative and non-cooperative solutions are compared through their fairness, spectrum utilization and throughput, both the approaches are considered such the cooperative approaches also consider the effect of the channel allocation on the potential neighbors. The results show that cooperative spectrum sharing outperforms the non cooperative spectrum sharing.

In spectrum sharing of the cognitive radio the third classification is based on the access technique.

1. Overlay Spectrum Sharing:

The cognitive spectrum devices may enhance and assist the non cognitive transmission rather than compete for spectrum access. Overlay spectrum sharing is one of the spectrum access techniques. In this method, the node accesses the network using a spectrum hole which is not used by the primary user, so that the interference to the primary user is reduced. An exchange should be carefully designed between the interference induced on the primary signal or licensed user and the improvement brought to it to achieve a stagnant SNR.

2. Underlay Spectrum Sharing:

Interference level at the primary user side remains acceptable when there are simultaneous cognitive and non cognitive transmissions allowed for a long interval. In the underlay spectrum sharing the node accesses the networks by observing the spread spectrum techniques developed for the cellular networks. When the spectrum allocation map is ready, the cognitive radio begins transmission. Due to this, at certain position, it will interfere with the primary user and causes interference. This solution needs increased bandwidth compared to the overlay technique.

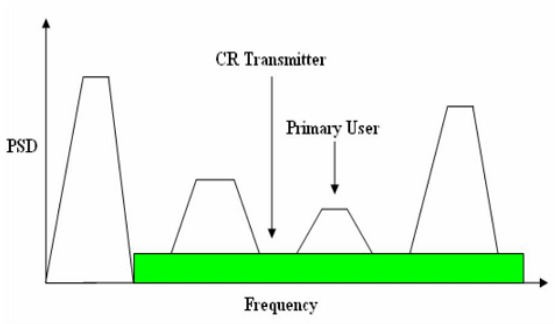

Fig.4 Underlay Spectrum Sharing [4]

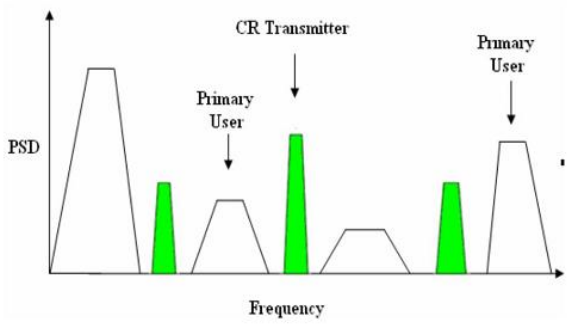

Fig.5 Overlay Spectrum Sharing [4]

Interweave Approach:

This approach has been proposed in the objective of entitling devices to take the spectrum rooms that has been left unoccupied by non cognitive users. We must able to predict the state of each portion of the frequency spectrum, portions of spectrum that are considered as being under-utilized may be accessed by secondary users as long as the primary activity remains idle. The coexistence of both primary and secondary

traffics within the same network in an opportunistic transmission mode, spectrum opportunities should be actively identified and monitored. This can be envisaged by combining both methods.

The existing spectrum sharing techniques are two types namely inter network and intra network spectrum sharing

1. Centralized-Intra-Network Spectrum Sharing:

In the centralized-intra-network spectrum sharing there exist a spectrum server and the spectrum server coordinates all the cognitive radio users. All users in this case exhibit the cooperative nature. [4]

2. Centralized-Inter-Network Spectrum Sharing:

The dynamics of the centralized-inter- network is similar to the intra network but in this case spectrum broker shares the spectrum among the cognitive radio users. [4]

3. Distributed-Intra-Network Spectrum Sharing:

In the distributed spectrum sharing technique no single entity makes the own sharing decision. Each cognitive radio user in the intra-networks plays their role in spectrum sharing process. [4]

4. Distributed-Inter-Network Spectrum Sharing:

In this case also each entity involves in the spectrum sharing decision. Each cognitive radio network plays their role in the spectrum sharing process. [4]

CONCLUSION

The scarcity of spectrum has created a need for greater flexibility in making use of new frequency bands while still maintaining the certainty and service quality supported by licensed spectrum. For instance, there are many situations in which a given frequency band is not uniformly used by a primary user in all locations and at all times. Commercial mobile broadband may be able to benefit by reusing such spectrum on a shared basis.

Spectrum can be shared in several discrete dimensions including: time, space and frequency. Current spectrum sharing schemes between disparate systems that operate within the same spectrum band may be achieved through a coordinated or an uncoordinated approach, or a hybrid combination of such mechanisms, depending on the desired coverage area and user base performance levels required.

Therefore, any spectrum sharing mechanism under consideration will likely require further technology research and development, testing and refinement to ensure that it provides sufficient protection to the primary users of the spectrum while providing beneficial new broadband capacity. Unproven assumptions about the operational environment create regulatory and technical uncertainty can impede investment and innovation by the private and public sectors.

APPENDIX

CR- COGNITIVE RADIO
SON- SELF ORGANIZING NETWORKS
MANET- MOBILE AD-HOC NETWORK
WSN- WIRELESS SENSOR NETWORK
HWN- HYBRID WIRELESS NETWORK
WANET- WIRELESS AD-HOC NETWORKS
SS- SPECTRUM SHARING
MCNS- MULTI-HOP CELLULAR NETWORKS
ICAR- INTEGRATED CELLULAR AD HOC RELAY
WMN- WIRELESS MESH NETWORK
ARS- AD HOC RELAY STATION
SNR- SIGNAL TO NOISE RATIO

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