UWB in Cognitive Wireless Communication

K. P. Joshi

Department of Electronics & Telecommunication Engineering, Pad. Dr. D. Y. Patil Polytechnic, Pune, Maharashtra, India

***Abstract*-** **Cognitive radio is a program for wireless communication in which a network or wireless node changes its transmission or reception parameters to communicate efficiently with licensed and unlicensed users by avoiding interference. Cognitive radio provides a solution of increasing spectral density by usage of frequency bands that are not heavily occupied by their licensed users. Cognitive radio using ultra wide band (UWB) is one of the best choice because very less interference, dynamically adjustable bandwidth and data rates.**

Keywords: **Cognitive radio; ultra wide band; spectrum sensing; spectrum shaping.**

I. INTRODUCTION

UWB is a wireless radio technology, uses very short pulses of radio energy with low probability of interrupt and excellent multipath immunity. It is developed to transfer large amount of data over short distances typically less than 10 meters. It is a technology offers a solution for a, power consumption, Bandwidth, cost and physical size requirements of next generation consumer electronic devices. Ultra wide band can be used at very low energy levels with high Bandwidth communications for short range, by using a large portion of the radio spectrum. This technology enables wireless connectivity across multiple devices and personal computers within the digital home and the office with consistent high data rates. Cognitive radio is a recent concept of wireless communication, which is highly economic and uses frequency spectrum very efficiently. In this technology, frequency bands which are not being used by the licensed users are utilized by cognitive radios for Transmission and Reception. Cognitive radios do not need to have licensed systems. In this technology, frequency bands which are not being used by the licensed users are utilized by cognitive radios for Transmission and Reception. Cognitive radios do not need to have licensed systems.

II. ULTRA WIDE BAND

UWB differs from narrowband radio frequency (RF) and spread spectrum technique (SS) such as Bluetooth technique and 802.11a/g. UWB uses an extremely wideband of RF spectrum to transmit data which makes UWB able to transmit more data over a given period of time than more traditional technique. The potential data rate is proportional to the Bandwidth of the channel and the logarithm of signal to noise ratio (Shannon's law).

$$\text{Channel Capacity } C = B \log_2 [1 + S/N] \quad (1)$$

UWB is a unique and new usage of a recently legalized frequency spectrum previously used in military Applications. UWB radio can use frequency from 3.1GHz to 10.6GHz.Each radio channel can have a Bandwidth of more than 500MHz or 20% of the center frequency.

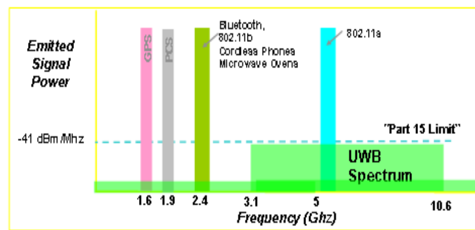

Fig. 1 Ultra wide band Spectrum

To allow such a large Bandwidth the Federal Communication Commission (FCC) put several broadcast power restrictions. By setting this restriction UWB devices can use a wide frequency band while not emitting enough energy to interfere with nearby other devices that use a narrowband of frequency such as Wi-Fi radios. Federal Communication Commission (FCC) defined the spectral mask of -41.3dBm/MHZ for the UWB transmissions in certain overlapping bands. For example, the radar and satellite systems span over a bandwidth of 1.6GHz (3.1 - 4.7GHz). Therefore, power control mechanisms and reduction of channel interference are important design issues in a UWB receiver.

A. UWB Data Rates

Ultra wide band is a new standard for devices that send very short pulses of information over small distances. It is an alternative to other wireless technologies such as Bluetooth and Wi-Fi that create Personal Area Networks (PAN).The principle advantages of UWB over these technologies are much faster data transfer rate i.e. 100Mbps or greater and extended device battery life. It may also offer a cost advantages if chipset production volumes are sufficiently high.

III. ULTRA WIDE BAND IN COGNITIVE RADIO

Devices using Cognitive radio technologies should have capability to determine their location; they should able to sense spectrum use by neighboring devices. They can change frequency, adjust the output power, and even they should able to alter transmission parameters and characteristics. A cognitive radio (CR) is a radio that interacts with other spectrum users and then accordingly can change transmitter parameters based on interaction.

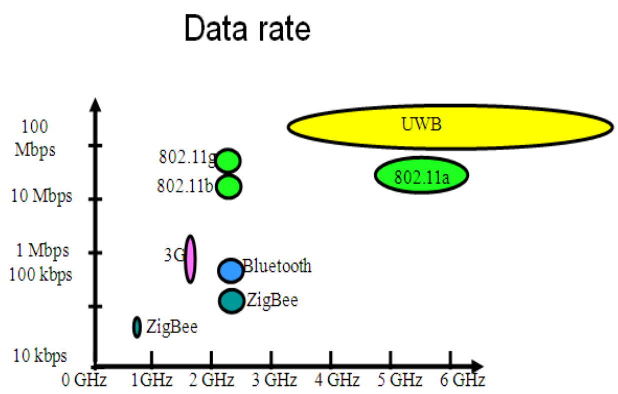

Fig.2 Data Rates between wireless systems3

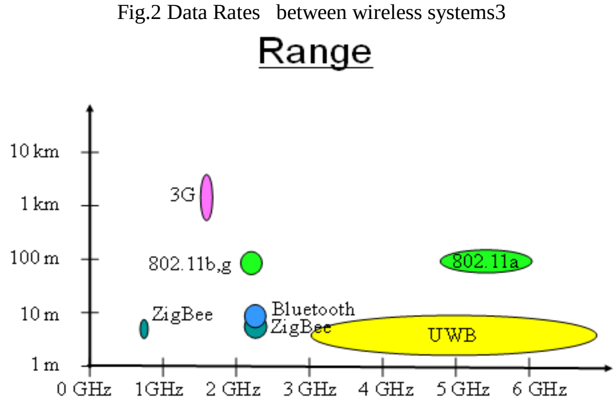

Fig.3 Range of wireless systems

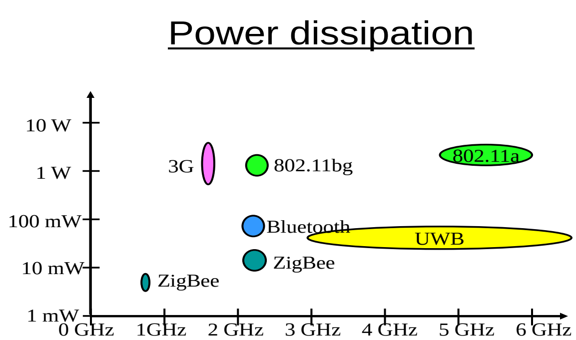

Fig.4 Power Dissipation of wireless systems

A. Cognitive Radio

The number of radio systems is increased; demand for frequency spectrum is also increased. Cognitive radio offers a perfect solution to this problem by using frequency bands appropriately that is not occupied by the licensed users. Modern wireless systems offering a wide variety of high data rate applications to numerous users at the same time. Since the number of wireless systems is increasing very rapidly, the limitation of the resources, especially for the frequency spectrum, becomes a more major problem day by day.

Cognitive radio is a concept that provides a solution on limitation of frequency spectrum by proposing an opportunistic spectrum usage approach. Since cognitive radios do not need to have licensed systems, so it is highly economic and provides efficient usage of the frequency spectrum. The primary properties of cognitive radio are its sensing, awareness, adaption and learning capabilities and memory. A cognitive radio system might be able to sense numerous factors such as spectrum, RF environment, the available nodes in its network and available power.

IV.OPPORTUNISTIC SPECTRUM USAGE

A. Spectrum Sensing

The first requirement for opportunistic utilization of owned bands is to periodically scan the spectrum and to detect the spectra that are temporarily not being used, which can be called White Bands. A commonly used name for this operation is spectrum sensing.

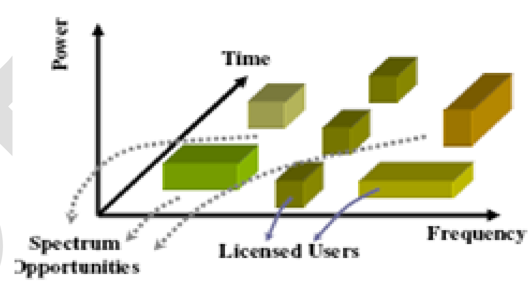

Fig.5 Spectrum Sensing

B. Spectrum Shaping

The second requirement for opportunistic spectrum usage is to dynamically adapt the transmission parameters to comply with the changing spectral conditions. A cognitive radio can accomplish this by modifying the shape of its transmitted pulse in such a way that the spectrum of the pulse fills the detected white bands as efficiently as possible.

C. UWB Transmitter and Receiver

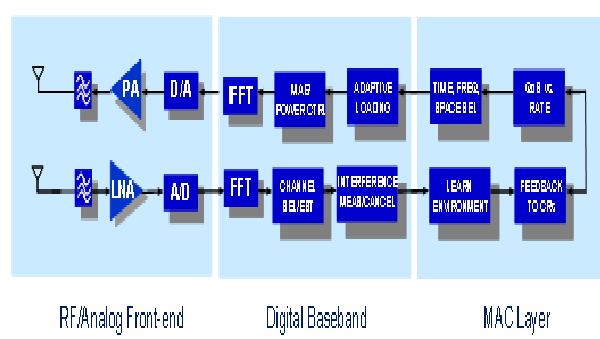

Fig. 6 Block Diagram of UWB Transmitter & Receiver

In the cognitive communications, it is assumed that both the transmitter and the receiver have transmission and reception capabilities. In order to match the result of the spectrum sensing operation done by both parties, each of them will transmit the information regarding the white spaces they have detected. The transmission of spectrum sensing results is done by via low power UWB signaling with on-off keying (OOK) modulation. that compiles with FCC regulations. Depending on the knowledge about the common white spaces, each party designs a new pulse shape. Since the new pulses designed by both parties will be the same, this method has the very advantageous feature that it enables highly efficient matched filtering during the real data traffic.

D. Cognitive Communications and Networks

In cognitive radio communications, in order to make sure that the intended frequency spectrum is not in use, both parties of communication have to scan the spectrum and inform each other about the spectral conditions. There should not be a gap between the sensing ranges of them. If the sensing ranges are not at least partially overlapping, there is always a risk that a licensed user located inside the gap between the sensing ranges is not detected. Therefore, the receiving sensitivity of both parties has an integral role in determining the range of communication. We assume high sensitivity around −120dBm to −130dBm and free space propagation, in which the transmitted power (Ptx) and received power (Prx) are related to each other by the Friis equation (ignoring the system loss and antenna gains) as given below in eqn.(2)

$$Prx = Ptx\ \lambda^2 / (4Л)^2\ d^2 \qquad (2)$$

Where λ is the wavelength and d is the distance. With these assumptions, it is seen that the scope of cognitive radio is limited to 50m to 150m, which is comparable to the range of WLANs. In a cognitive network whose nodes communicate with each other using UWB to exchange spectrum information. The fact that UWB signaling is proposed may seem to be contradicting with the aim of increasing the range of cognitive radio because of the limited range of UWB.

The bit error rate (BER) expression for OOK modulated UWB signals as given below in eqn.(3)

$$BER = Q\ (\sqrt{NsAEp/2N_0}) \qquad (3)$$

where Ns is the number of pulses per symbol, A is the pulse amplitude, Ep is the received pulse energy, and the additive white Gaussian noise (AWGN) has a double sided spectrum of N_0, it is seen that increasing Ns, which can be accomplished by repeated transmission of data, results in lower BER. This fact leads to a very advantageous feature of UWB called *processing gain*. By applying the necessary amount of processing gain, it can be made possible that the farthest nodes in a cognitive network can share the spectrum sensing information. Although this comes at the expense of lowered throughput, it is not a limiting factor in this case because a quite low data rate is enough to transmit the spectrum sensing information.

The sensing information received from all the other nodes in the network can be combined in each node, and pulse design can be done according the common white spaces. This way, the range of cognitive communications can be extended to the coverage area of a medium-sized network. If the network size is increased probability of overlapping with licensed systems is also increased.

This fact sets a practical limit to the size of the cognitive network, because continuing to enlarge the network, the common white bands become less and less, and after some point their amount becomes insufficient to ensure the minimum quality of service. For the details of how the common white bands are going to be shared by the cognitive nodes in the network.

V. CONCLUSION

UWB Technology can support many applications. Different UWB modulation schemes offer different advantages for communication, radar, and precision geo-location applications.UWB offers a low probability of intercept and a low probability of detection . Thus, it is particularly well suited for covert military or sensitive usage scenarios. As UWB signals have extremely short bursts in time (e.g., durations of 1 ns or less) they are suited for precision geo-location applications. Data Rate of UWB is of 100Mbps which is higher than other wireless technologies even of 802.11g Standard.UWB is restricted because of its limited range of up to few meters but it requires less power. Cognitive radio using ultra wide band is one of the best choice because very less interference, dynamically adjustable bandwidth and data rates. The range of cognitive radio is limited to 50m to 150m. To enlarge the network, the common white bands become less and less, and after some point their amount becomes insufficient to ensure the minimum quality of service.

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