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Research Paper Engineering

Cognitive Radio

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ABSTRACT

Federal Communications Commission (FCC)'s spectrum allocation chart shows that many frequency bands are being allocated to multiple incumbents, overlapping each other. While most frequency bands are licensed, studies suggest utilization rates are between 15% and 85%.

Cognitive radio (CR) has been highlighted as a possible candidate in improving spectrum utilization by providing opportunistic spectrum access. A cognitive radio can be defined as a radio that is able to Unlicensed spectrum is becoming increasingly scarce, especially those under 3 GHz. Before a CR can utilize any free frequency, it must first be able to detect these un-utilized spectrums. The following section will describe what cognitive radio technology is and also the reason behind why such a technology came into existence. mainly in our project we are trying to implement the spectrum sensing technique in cognitive radio with one of the many types present and that is ENERGY DETECTION TECHNIQUE., which was carried in frequency domain to get the power spectral density.

Keywords : Cognitive Radio

1. Introduction to Cognitive Radio

The rapid growth in wireless technologies has intensified the demand for the radio spectrum. On the other hand, the research studies reveal that the spectrum utilization is unevenly distributed, which leads to the conclusion that there is a problem with the spectrum management and allocation rather than the scarcity of the spectrum itself.

Cognitive radio is arriving on the heels of Software Defined Radio (SDR) technology and building on it. This new wireless paradigm (standard) involves SDR systems that can reconfigure their analog RF output and that incorporate "self-awareness" and knowledge of transmission protocols, etiquette and procedures.

These developments will yield a cognitive radio able to sense its RF environment and location and then alter its power, frequency, modulation and other operating parameters so as to dynamically reuse whatever spectrum is available.

A cognitive radio will be able to autonomously sense how its RF environment varies with position and time in terms of the power that it and other transmitters in the vicinity radiate. These data structures and related software will enable a cognitive radio device to discover and use surrounding networks to the best advantage while avoiding interference from other radios. In the not too distant future, cognitive radio technology will share the available spectrum optimally without instructions

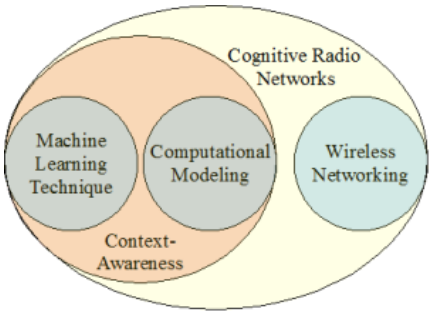


Figure: Cognitive Radio

2. History of cognitive radio

The idea of cognitive radio was first presented officially in an article by Joseph Mitola III and Gerald Q. Maguire, Jr in 1999.

Regulatory bodies in various countries including the Federal Communications Commission in the United States, and Ofcom in the United Kingdom found that most of the radio frequency spectrum was inefficiently utilized as shown in figure 1.1Independent studies performed in some countries confirmed that observation, and concluded that spectrum utilization depends strongly on time and place. Moreover, fixed spectrum allocation prevents rarely used frequencies (those assigned to specific services) from being used by unlicensed users, even when their transmissions would not interfere at all with the assigned service. This was the reason for allowing unlicensed users to utilize licensed bands whenever it would not cause any interference (by avoiding them whenever legitimate user presence is sensed). This paradigm for wireless communication is known as cognitive radio.

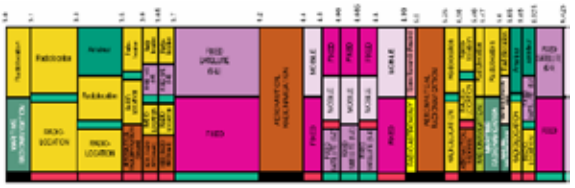


Fig 1.1: Frequency allocation

It is commonly believed that there is a spectrum scarcity at frequencies that can be economically used for wireless communications. This concern has arisen from the intense competition for use of spectra at frequencies below 3 GHz. The Federal Communications Commission's (FCC) frequency allocation chart indicates overlapping allocations over all of the frequency bands, which reinforces the scarcity mindset.

Regulatory agencies, such as the Federal Communications Commission (FCC), allocate spectrum for particular types of services that are then licensed to bidders for a fee. Those allocations and licenses are static in nature, which means that this spectrum is unavailable for use, even if those who own the rights to that spectrum do not use it.

This has led to considerable inefficiency in spectrum utilization, and has created an unnecessary shortage of spectrum. This issue has been temporarily alleviated by providing for the availability of spectrum for unlicensed usage, and has fuelled the global deployment of 802.11-based technology.

3. Definition :

Cognitiveness: This term refers to mental processes of perception (sensing), memory, judgment, and reasoning.

Cognitive radio is a paradigm for wireless communication in which either a network or a wireless node changes its transmission or reception parameters to communicate efficiently avoiding interference with licensed or unlicensed users. This alteration of parameters is based on the active monitoring of several factors in the external and internal radio environment, such as radio frequency spectrum, user behaviour and network state.

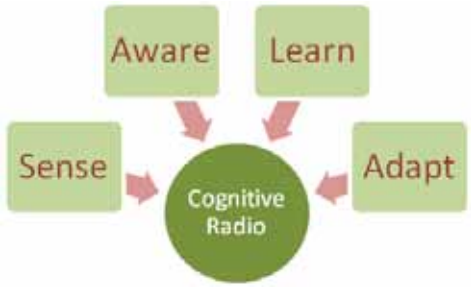


Fig 3.1: Cognitive radio layout

CR can sense its environment and without the intervention of the user can adapt to the users communication needs while conforming to FCC rules. Conceptually, the amount of spectrum is infinite, practically for propagation and other reasons; it is finite because of the desirability of certain portions of the band. Even the spectrum which is assigned is far from being 100% utilized, hence efficient use of the spectrum is a growing concern. CR offers a solution to this problem. A CR can intelligently detect whether any portion of the spectrum is in use or not, and can temporarily latch into or out of it without interfering with the transmissions of other users thereby efficiently utilizing spectrum.

The potential for Cognitive radio is a novel efficient methodology, extension of software-defined radio, to transmit and receive information over various wireless communication devices. Being aware of the existing operators in the environment, Cognitive radio chooses the best available option based on performance for each application. The different performance measuring parameters include frequency, power, antenna, transmitter bandwidth, modulation scheme etc.

This means that the said radio has to deal with different RF spectrum and baseband varieties at the same time, thus requiring a more robust, efficient and reconfigurable hardware architecture. Clearly, the introduction of this revolutionary paradigm poses many challenges across all layers of a cognitive radio system design like spectrum sensing, interference management, resource allocation, RF design and implementation issues.

4. Cognitive Radio Network Architecture

According to FCC, several parts of the fixed spectrum are under-utilized while some spectrum bands are heavily used and subject to high interference. Temporarily unused spectrum bands (a.k.a. spectrum holes or white spaces) can be used by opportunistic radios to improve the overall spectrum utilization. Hence, new spectrum allocation methods and technologies are necessary to maximize the benefits of the limited spectrum resource by learning the unused spectrum bands in given time and location. Dynamic Spectrum Access (DSA) technique aims to solve spectrum allocation problems.

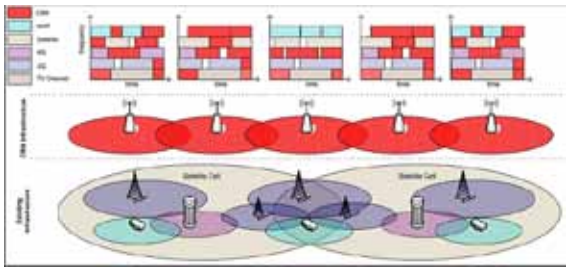


Figure: CRN frequency usage example.

In the architectural foundation, we define some network agents to manage and support DSA nature of cognitive networks. The following terms are necessary for our proposed architecture:

Frequency Holder (FH): FH represents the institution that has the right of using a spectrum band in a particular region by a long term leasing agreement with the governmental agencies.

Spectrum Broker (SB): SB is a network agent that interconnects wireless spectrum holder and the CR users.

Cognitive Radio Service Provider (CRSP): CRSP is an entity that provides cognitive radio services.

Cognitive Radio Service Provider Network (CRSPN): CRSPN is a cellular network which covers a broad geographical area and provides communication service for cognitive radios. A CRSPN can be owned by a CRSP or may be shared between some CRSPs. Moreover, establishment of these networks by some third party institutions is also possible. These institutions provide leasing of their networks by CRSPs.

Cognitive Radio Mobile Terminal (CogMT): Defined as an intelligent wireless communication device that works on Software Defined Radio (SDR) physical platform.

Cognitive Base Station (CogBS): CogBS works as a connection point that ties CogMTs to CRSPN and responsible for handling traffic and signaling between a CogMT and the CRN.

5. Classification

Depending on the set of parameters taken into account in deciding on transmission and reception changes, and for historical reasons, we can distinguish certain types of cognitive radio. The main two are:

- Full Cognitive Radio ("Mitola radio"): in which every possible parameter observable by a wireless node or network is taken into account.

- Spectrum Sensing Cognitive Radio: in which only the radio frequency spectrum is considered.

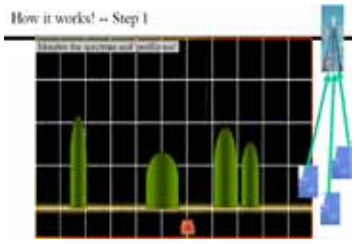
Also, depending on the parts of the spectrum available for cognitive radio, we can distinguish:

6. Working of Cognitive Radio

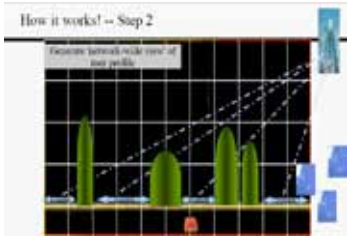
The basic idea behind why this technology became so known is just because of how it functions, that is how works and i.e. how it finds or detects the spectrum holes, and adapts quickly to the current radio environment and accordingly change it transmission and reception parameters to make use of the spectrum efficiently.

Basically cognitive raduio works mainly in four aspects.firstly we scan the whole spectrum and find out the free bands ie the white bands then we fill the bands with dynamic hopping sequence and finally transmitted.

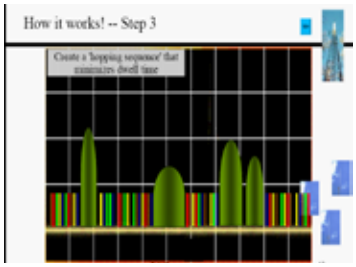
MAIN FOUR STEPS OF WORKING ARE :



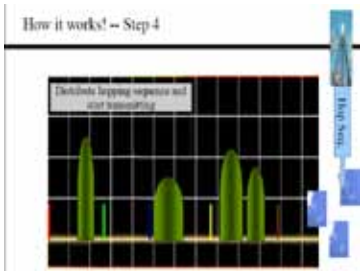
1.SCANNING OF BAND



2.FINDING WHITE SPACES



3. FILLING OF BANDS



4. TRANSMITTING DATA

6.1 Spectrum Sensing

It means detecting the unused spectrum and sharing it without harmful interference with other users, it is an important requirement of the Cognitive Radio network to sense spectrum holes, detecting primary users is the most efficient way to detect spectrum holes. The four main parts are described in figure 6.1

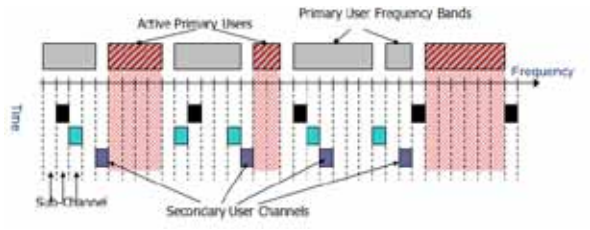


Fig 6.1: Spectrum sensing

One of the defining functions of a cognitive radio is the ability to sense the radio channel in order to find opportunities in spectrum and adapt the radio parameters. Figure 6.1 illustrates how a band is scanned and how we can detect the primary users. Recent measurements have shown that the spectrum usage is concentrated on certain portions of the spectrum while a significant amount of the spectrum remains unused. These holes can be classified into three types:

1. Black spaces, which are occupied by high power interferes some of the time,

2. Grey spaces, which are partially occupied by low power interferes,

3. White spaces, which are free, no one send information on this band, but it is occupied by natural and artificial forms of noise (e.g. thermal noise, transient reflections...). Black spaces is obvious forbidden to send on it because of the high power interferes, so the whites and the Grey spaces are the candidates for use by unlicensed operators. Spectrum sensing has been identified as a key enabling cognitive radio to not interfere with primary users, by reliability detecting primary user's signals.

In cognitive radio (CR) networks, unused spectrum bands will be spread over a wide frequency range including both unlicensed and licensed bands. These unused spectrum bands detected through spectrum sensing show different characteristics according to the radio environment.

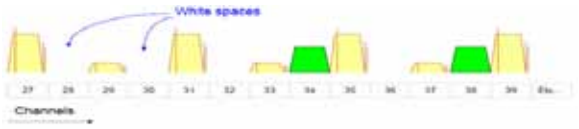


Fig 6.2: White spaces

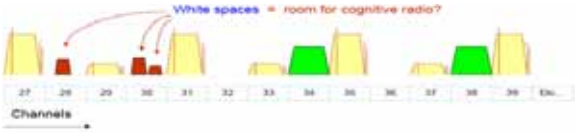


Fig 6.3: Spectrum Filling

The above figure 6.2 and 6.3 shows the filling of the white spaces present in the spectrum. This whole process is carried out by cognition cycle where the radio senses the spectrum under consideration, and then it finds out the spectrum holes information and depending on that the channel capacity and finally takes the decision whether to transmit its own signal or not. This process is in figure 6.4.

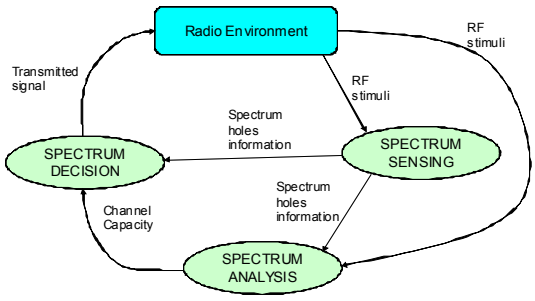


Fig 6.4: Cognitive Cycle

- **Spectrum Sensing Techniques**

The process of detecting the white spaces is basically carried out by various spectrum sensing techniques. The techniques employ processing on the signals by finding different signal properties like power spectral density or may be the correlation of it.

- **Conclusion**

Few applications of Cognitive Radio are:

1. Non real-time applications (e.g., mobile multimedia downloads, email)

2. Broadband wireless networking in hotspot locations

3. Localised wireless multimedia distribution networks

4. The FCC is beginning to open up the regulatory landscape for more extensive applications of cognitive radio technologies.

5. The FCC is looking for innovative ways to enable “the next new thing” in spectrum management and commercial wireless activity

6. IEEE 802 is moving with the regulatory process to bring cognitive techniques into new networking standards

7. With wireless and radio communication becoming far more widely used, ideas such as Cognitive Radio will become more important.

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