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Cognitive Radio Applications of Spectrum Occupancy in HILLAH-IRQ Measurement and Analysis

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Abstract:

Spectrum scarcity and underutilization are just two issues that cognitive radio (CR) technology has shown promise in addressing. Understanding the present level of frequency, time, and geographic spectrum consumption can help with CR network installation. Based on extensive spectrum measurements made over a long period of time using the energy detection method, we assess the spectrum use of a few chosen bands in HILLAH, IQ, in this study. This study shows that some licensees' spectrum is being used way too little, which CR can take advantage of for effective spectrum use.

INTRODUCTION

The radio spectrum, a scarce and possibly uncommon real resource, is contested by numerous systems in the communications ranges. The growing requirement for broadband wireless services is the primary cause of the increased demand for radio spectrum. Recent spectrum studies, however, have shown that the majority of the authorized spectrum is significantly underutilized. The fixed frequency allocation and growing wireless technologies with high bandwidth requirements are to blame for the current perception of spectrum scarcity. Recent auctions of small radio spectrum blocks for 3G, 4G, and 5G systems took place in a number of places throughout the world, and large amounts of cost were spent to get permits to utilize the entire spectrum. Although the conventional usage method of spectrum allocation, which assigns the license holder a fixed allocation, reduces interference, it does not allow for flexible and efficient radio spectrum utilization. The usage of cognitive radio (CR) systems has the potential to considerably enhance the allotted and unused main systems' range. Some measurements of global measurements of spectrum occupancy. a time-tested management proverb that is still relevant today is that If you don't measure it, you can't manage it. In order to determine the extent of radio spectrum consumption in a particular area and, as a result, to analyze the foundations a campaign of experimental measurements of actual wireless spectrum administration has been carried out. Access to unlicensed, opportunistic spectrum is the foundation of CR (OSA), when time and place permit.

Authorized frequency bands may be used as long as licensed users are not damaged by interference. The current methods of spectrum allocation practices that emphasize spectrum granulation are very dissimilar from the novel approach of dynamic bandwidth utilization. One of the main elements influencing the current global switchover of TV broadcasts the shift from analog to digital systems is the expansion of CR research. Hence, precious spectrum is released. Allowing unauthorized users to access the licensed bands in a properly managed manner is one way that CR can be used to significantly improve spectral efficiency. In an effort to avoid any damaging The primary (licensed) system should not be impacted by CR equipment, and capability stated in the following parts.

A TESTING SETTING FOR MEASURING RF POWER

RF signals from the actual world were recorded for two months using the universal software radio peripheral 1 (USRP 1) to create the datasets used in this investigation. Software-defined radios are the USRP that are hosted on computers. They have a single modular daughter board and a motherboard different frequency bands. The RF front end is made up of the daughter board modules. In this study, two daughter boards utilizing constant frequency varies of 60 MHz to 970 MHz were used. While the motherboard handles analog to digital conversion (ADC), power management, host processor interface, and digital clock generation and syncing to analog conversion (DAC). The signal is also decimated to a lower sample rate for speedy software processing on the host computer after being promptly delivered via a elevated USB cable. The following frequencies are the main subject of this study: 60–760 MHz, 768–875 MHz, 2.5–2.77 GHz, and 3.1–3.4 GHz bands are all used. The bandwidth of a TV channel is 8 MHz, while that of the GSM, 1800GSM 900, and FM bands is 195 KHz, and that of ISM 860 is 30 KHz. We divided the spectrum into subchannels that were 300 KHz broad, which IJS dubbed resource blocks. 512 samples were collected for each sample time using a 1MHz sample frequency to make sure that none of the spectral data is lost. Since there are 256 frequencies for each 300 KHz resource block, bins, this results in an incredibly high-resolution frequency of 2.21 KHz. The study's examination of the smallest (30 KHz) channel bandwidth has a 2.21 KHz frequency resolution, which is more than sufficient to include all of the spectral information of the carriers. Without sacrificing generality, the capturing was limited RF signal in a particular band to use a channel filter to collect one unit of resources at a time; as a result, the sample rate is easily processed by the host computer while maintaining a high frequency resolution. However, the temporal (time) precision decreases with increasing frequency resolution. The frequency domain data as well as the time domain data were used to determine the power. a number at random between 5 and 30 seconds. The assumption that any TV show, FM broadcast, or GSM call will endure for at least 5 to 30 seconds led to the selection of this range. Rather than employing set times apart, the duration between consecutive samples of inside the specified range, information is randomly selected. in order to catch all potential trends. The experimental environment is represented in Figure 1 displays some of the bands that were recorded for this prosecution's RF intensities.

Fig. 1 shows the measurement tools used in this research. Antenna, computer, and spectrum analyzer.

Indoors at the Centre for Computational Intelligence, the experiment was undertaken. Babylon University, Gateway House, Hillah, Iraq (GPS location: Lat.32° 27' 40.6368" N, Long 44° 25' 1.4196" E). Gnu-radio, that combines Python and C++, was used to accomplish the data collection and signal processing.

SETUP FOR MEASUREMENT

Table I is a list of the primary parameters for the spectrum analyzer's setup. considering the range of each band's transmitter signal and local spectrum allocations, the measuring frequency band was divided into several sections. For instance, the frequency bin for the measured GSM/DCS bands is 50 Hz/(444-1) = 90 kHz, This is less than the GSM/DCS signal's 200 KHz RF bandwidth. Similar to this, UMTS band (5MHz RF bandwidth) and TV bands (8MHz bands) were measured using 745.5KHz and 727.3KHz bins, respectively. Each block's measurements were taken throughout a 24-hour period.

TABLE I- CONFIGURATION Of SPECTRUM ANALYZER

Parameter	***Value***
Range of Frequency	*185- 2750 MHz*
Frequency bins	*Variable (55-700)/ (82-1060.5 kHz)*
(RBW/VBW) Resolution	*29 kHz/ 28 kHz*
Time of Sweep	*(selected Automatically*
Reference Level	*-15 dBm*

AVERAGE ESTIMATE FOR SPECTRUM OCCUPANCY AND USE

Among the CR's key duties, spectrum monitoring determines whether the PU is occupied (RF activity). A binary classifier is used to categorize the channel as busy or idle based on the results of the sensing. Wavelet-based estimation using Detectors for energy, correlation-based properties, joint sensors, tournament filters, eigenvalues, and multitaper spectrum assessment are just a few of the detection techniques that have been proposed [10]. The energy detector is the only one of the suggested approaches to be employed in this investigation because it doesn't need for any prior understanding the PU signaling. The most difficult aspect of the perception of energy is choosing the right threshold so if Once energy exceeds a certain threshold, If a channel is crowded, it is considered to be congested (vacant) If When the limit has been set too little, there is a high likelihood of wrong alarms (false positives), which involve proclaiming an empty channel to be busy (free). Although this is secure for the PU, it wastes a chance for communication with the SU (CR) and results in low spectrum usage. Nevertheless, if the threshold is set too high, a channel may be declared idle when it is actually busy since a faint PU signal won't be picked up. This is known as a false negative. This suggests significant PU interference and lost data or communication to the CR. Although there is currently active study into the ideal threshold, the International Telecommunication Union has advocated an empirical approach (ITU), [11]. According to the ITU, the threshold should be 10 dB over background noise. Experimental evidence has shown that an ambient noise threshold of 10 dB will, in most situations, result in an extremely low likelihood of false alarm of roughly 0.0005%. Even for the same band, the background noise is not constant; it varies with frequency, time, and place. The best threshold hold option will rely upon relation to the costs of false alarms and missed detection, according to this empirical advice. In place of adopting a consistent limit over the entire band as done in [15], for increasing the precision of the spectral utilization calculation there is a threshold for every frequency subframe (295 KHz). A 50-smart antenna terminator is used in place of the antenna to obtain the ambient noise levels. As a result of the noise floor's frequency dependence, (f), the threshold T(f) changes with frequency. To make sure the threshold complies with the We keep a set margin M(f) amount of 10dB. in accordance with ITU standards, taking into account the gain added by the USRP's operating codes. The cutoff is given by (1)

$$T(f)=\varrho(f)+M(f) \quad (1) \qquad (1)$$

Where M(f) is a fixed margin's values are determined by the expected chance of a technical glitch, where (f) represents the typical environmental power of noise of the supplied foundation network f, and (f) is a flow rate frame's threshold f, and we calculate every channel's or service frame's duty cycle in order to calculate the spectrum or channel availability (utilization). The duty cycle refers to the proportion of time the channel is occupied. If the threshold is and the adjustment problems at frequency f are Pi(f), (f). With frequency f at the i-th test, the immediate spectrum occupancies rate Bi(f) is reported (2). $B_i(f) = \begin{cases} 1\ if\ p_i(f) > T(f) \\ 0\ Otherwise \end{cases}$ (2)

The binary statuses for busy and idle (empty), respectively, are 1 and 0, where I is the time index. Threshold T(f) The provided blockage p_i is the threshold for this spectrum occupancy campaign. The estimate of the channel's simultaneous rate of utilization during the entire time span is the channel duty cycle, or supply blockage duty cycle, as shown in (3).

$$\Psi(f) = \frac{\sum_{i=1}^{n} B_i(f)}{n} \quad (3)$$

Where n represents the total number of time intervals used to test or monitor the channel, the duty cycle represented by (f) is of the subframe or channel f. The range spectrum duty cycle is defined as the estimate of the channel or service unit duty cycles inside the range (4). This provides an evaluation of the spectrum utilization for the range (utilization). As a result of the foregoing, the highest possible duty cycle is 1, making the result of the DC of the estimated amount of range utilization in Hz provided by the band and its frequency range (bandwidth). The level of occupancy or use of a band increases linearly with the duty cycle amount of the band.

$$\Phi(b) = \frac{\sum_{i=1}^{N} \psi_i(f)}{N} \quad (4)$$

(b) is the range b duty cycle and N is the total number of channels or resource blocks whose power measurements were obtained.

FINDING THRESHOLD

There are several distinct approaches suggested for determining the presence of signal transmissions. Several methods involve analyzing a channel's signals to identify the signal type and channel occupancy. It has been suggested that CR systems use a variety of techniques to assess if a channel is utilized or accessible at any time. They include the Wavelet transform-based estimation [17], Multitaper spectrum estimation [16], cyclostationary detection method [15], the way of detecting energy (ED)[13], Matching of filtering (MF) approach [14], and MF-based method [14]. Only energy-based detection techniques don't need to know anything about the signal beforehand. This approach is used to assess the utilization in the various frequency range. The choice of an appropriate unit of quantification is a crucial part of measuring. A threshold that is set too low will arise the likelihood of erroneous positives or determining that When a channel is not actually occupied. This might be brought on by strong noise samples and result in channel occupancy being overrated. In opposition to that, when the threshold value is set very high, poor signals can be mistaken for real occupancy and noise might be underestimated. Despite the fact that threshold setting is a hot topic for research right now, there are primarily two schools of thought: analytical and empirical. ITU recommendation: the threshold should be 10 dB above background noise (ITU Handbook Spectrum Monitoring, p. 168). The relative costs of false positives and other factors influence the best threshold to use.

RESULTS

It is clear from the latest survey on spectrum occupancy shown in Figs. 2 and Fig. 3 that some bands are blatantly underutilized in comparison to the International Telecommunication Union's (ITU) suggested level. Whereas Fig. 2 and Fig. 3 show the usage level channel within the bands. In the FM spectrum, only one channel (107.5MHz) is used, with the possible exception of low-power devices, as seen in Fig. 5. The spectrum was split into two groups, 120-243 MHz and 250-480 MHz, which were used for astronomical objects and meteorological aids as well as a satellite of

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meteorological, a satellite of mobile, space research, and aeronautical, land, and marine mobility. The television spectrum, 471-862 MHz, was classified into three bands, 472-603 MHz, 603-725 MHz, and 725-861 MHz, which are used for mobile communication, aeronautical radio navigation, and other PMSE applications. Fig. 3 shows the band, which has a duty cycle of 28.52%. With a duty cycle of 18.55 percent in our research a greater spectrum occupancy is seen in the ISM 2.5 GHz band than in the ISM 860 MHz band, which has a duty cycle of 14.61 percent. These results proved that the spectrum shortage is a direct result of a static spectrum allocation strategy rather than being caused by a basic shortage of spectrum.

Conclusions

The spectrum occupancy survey described in this research sought to identify underutilized bands that would be candidates for cognitive radios to use (CR). This research shows that bands 49 - 500 MHz, with an average occupancy of 4.1%, are chronically underutilized. 20.60% is the band's duty cycle between 500 and 900 MHz. In comparison to other bands reviewed in this study, the GSM 1800 and GSM 900 bands are the most frequently used. Bands between 50 and 900 MHz are prospective potential bands for CR using, according to the results of our study location. Measurements will be made simultaneously at various heights across a number of distinct locations within the same time frame for feature work. This will facilitate the provision of a more comprehensive spectrum occupancy estimate that can make it easier to create cognitive radio networks.

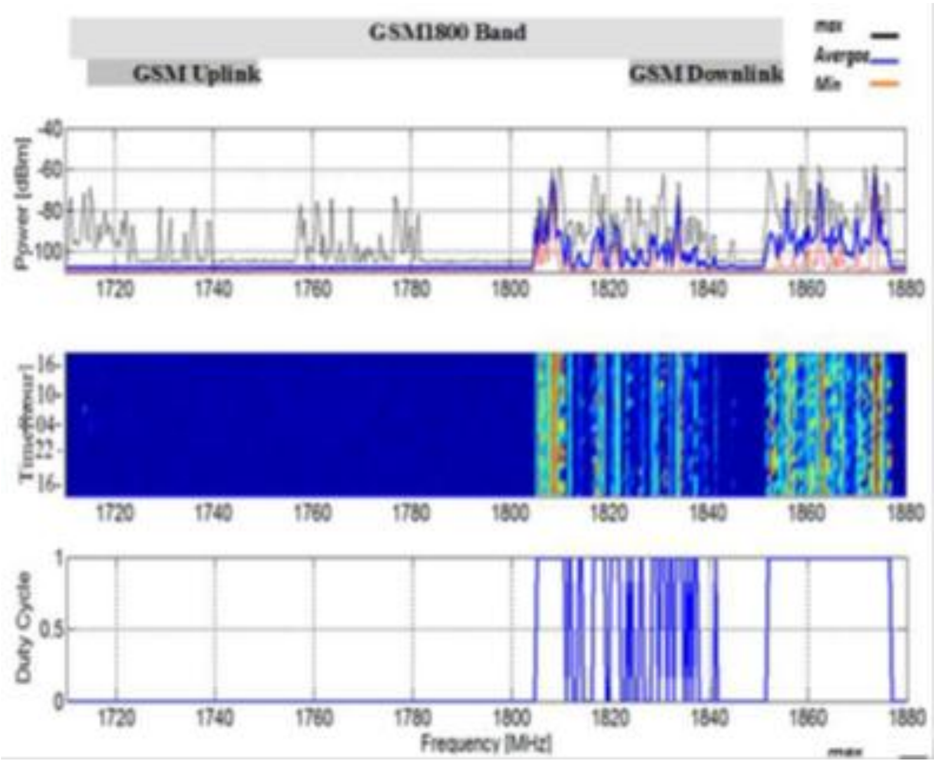

Fig. 2 measurement of occupancy from 1710MHz to 1880MHz

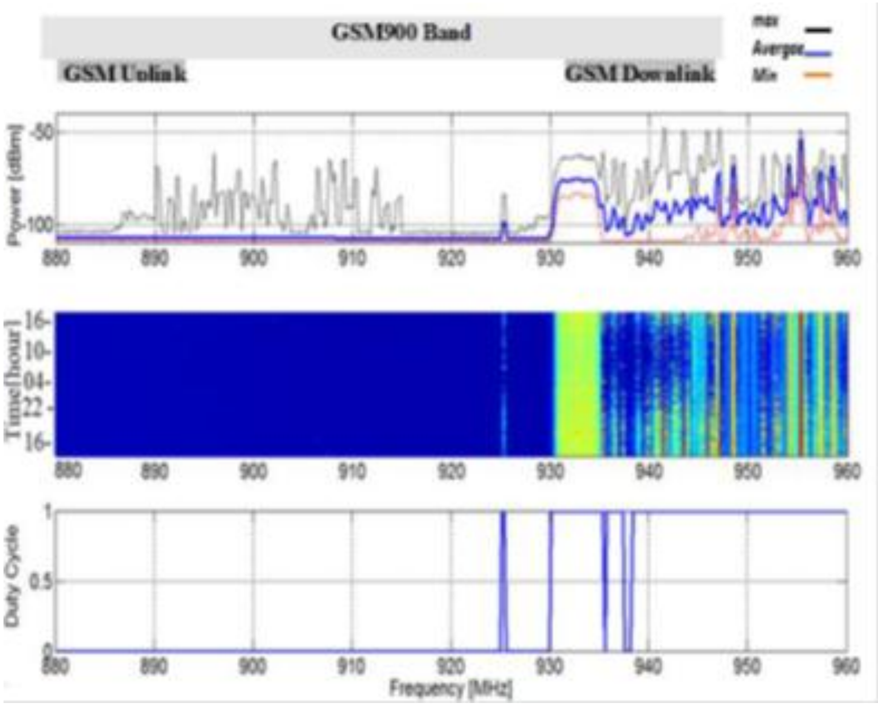

Fig. 3 Measurement of occupancy between 880 and 960 MHz

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