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PERFORMANCE ANLYSIS OF EFFECTIVE ENERGY DETECTION BASED SPECTRUM SENSING IN COGNITIVE RADIO

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ABSTRACT

Spectrum sensing can be characterized as inspecting the radio range to focus the utilized or unused recurrence groups. In EW applications, it is utilized to discover the possessed recurrence groups in the range, though in cognitive radio, it is connected to identify the abandoned recurrence groups to convey. Spectrum sensing and restriction are additionally actualized in cognitive radios, which can be characterized as keen radios being able to be mindful of the electromagnetic environment. Optional clients, additionally called unlicensed clients, actualize range sensing and some of the time restriction to utilize the authorized range groups without meddling with the essential clients having need of administration. Specifically, optional clients use range sensing to discover empty recurrence groups where correspondence is conceivable. As in RF sensor systems, participation in range sensing and restriction enhances the execution of cognitive radio systems. This task executes range sensing assignment by dissecting the executions of a radio recurrence sensor arrange through recreation. A recreation model is made in MATLAB programming dialect.

KEYWORDS: Spectrum sensing, RF sensor systems, EW applications, Energy Detection, Unlicensed Clients, Cognitive Radio.

INTRODUCTION

According to survey of Federal Communications Commission (FCC) in 2002, it has been found that spectrum access is more significant problem than physical scarcity of spectrum. With many technological advances in the field of wireless communication and 3G, 3.5G, 3.75G and 4G technology already being employed Multimedia Broadcast and Multicast Services (MBMS) demand has tremendously increased and with the standardization of MBMS it has gained significant interest in the market. Multimedia content requires more bandwidth, storage capacity and few applications pose tight delay constraints, so the need to optimize the utilization of spectrum is felt all the more.

Cognitive radio (CR) has turned into a developing propelled radio innovation that empowers a radio gadget to screen, sense, recognize and self-sufficiently adjust its correspondences channel access to the element radio recurrence (RF) environment in which it exists. As it were, CR gadgets can sense, distinguish, and screen the encompassing RF conditions including impedance and access accessibility and reconfigure their own particular working qualities to best match those conditions. It emerges to be an enticing answer for ghastly gathering issue by presenting the crafty use of recurrence groups that are not vigorously possessed by authorized clients since they can't be used by clients other than the permit managers right now.

COGNITIVE RADIO

Cognitive Radio (CR) is a framework/model for remote correspondence. It is based on programming characterized radio which is a developing innovation, giving a stage to adaptable radio frameworks, multiservice, multi-standard, multiband, reconfigurable and reprogrammable by programming for Personal Communication Services (PCS). It utilizes the philosophy of sensing and gaining from the earth and adjusting to factual varieties continuously. The system or remote hub changes its transmission or gathering parameters to impart effectively anyplace and at whatever time keeping away from impedance with authorized or unlicensed clients for effective usage of the radio range.

Cognitive modules in the transmitter and receiver must work in an agreeable way which is attained to by means of a criticism channel joining them. Receiver is empowered to pass on data on the execution of the forward connection to the transmitter. Consequently CR by need is a case of an input correspondence framework. A cognitive radio is additionally characterized as a handset that naturally changes its transmission or gathering parameters, in a manner where the remote correspondences can have range dexterity as far as selecting accessible remote channels sharply. The fundamental procedure is likewise called dynamic spectrum management.

In light of FCC's regulation for the radio range, a certain recurrence band must be involved by the particular authorized clients, who have full benefits on the range access to this recurrence band. It is plainly said in numerous reports that the range under the present regulation is either under-used or un-used by its authorized clients. In the mean time, numerous other unlicensed clients need to utilize this under/un-used range however are not ready to do as such simply in light of the fact that they have no benefit to utilize the range. In light of this issue, FCC opened free 'white space' range and presented Cognitive Radio

COGNITIVE CYCLE

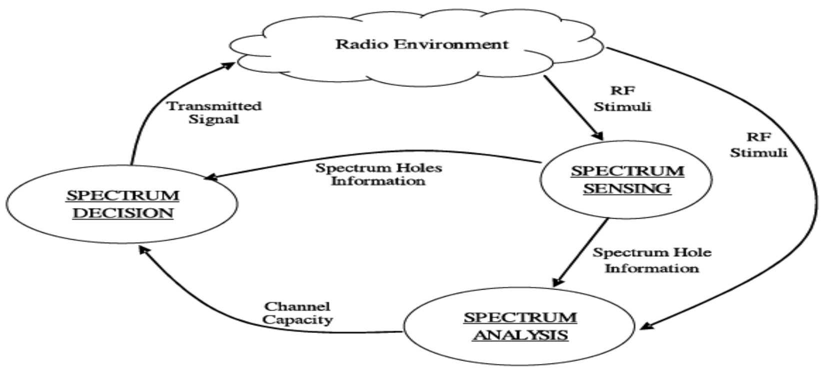

Figure 1: Cognitive cycle

A basic cognitive cycle comprises of following three basic tasks:
- Spectrum Sensing
- Spectrum Analysis
- Spectrum Decision Making

SPECTRUM SENSING

Spectrum sensing is the capacity to quantify, sense and be mindful of the parameters identified with the radio channel attributes, accessibility of range and transmit power, impedance and clamor, radio's working surroundings, client prerequisites and applications, accessible systems (bases) and hubs, neighborhood arrangements and other working limitations. It is carried out crosswise over Frequency, Time, Geographical Space, Code and Phase.

TYPES OF CR SPECTRUM SENSING

There are various routes in which cognitive radios have the capacity to perform range sensing. The routes in which cognitive radio spectrum sensing can be performed can be categorized as one of two classes:

COOPERATIVE SPECTRUM SENSING: Within an agreeable cognitive radio spectrum sensing framework, sensing will be embraced by various diverse radios inside a cognitive radio system. Commonly a focal station will get reports of signs from a mixed bag of radios in the system and conform the general cognitive radio system to suit. Cognitive radio participation diminishes issues of impedance where a solitary cognitive radio can't hear an essential client due to issues, for example, shading from the essential client, however a second essential client going about as a collector may have the capacity to hear both the essential client and the sign from the cognitive radio framework.

NON-COOPERATIVE SPECTRUM SENSING: This type of spectrum sensing, happens when a cognitive radio follows up on its own. The cognitive radio will arrange itself as per the signs it can distinguish and the data with which it is preloaded.

ENERGY DETECTION

Energy Detection, also known as radiometry or period gram, is the most common way of spectrum sensing because of its low computational and implementation complexities. Energy detection is an attractive spectrum sensing method for cognitive radio. The design of energy detection relies on two critical assumptions: 1) noise power is perfectly prior

known 2) the test statistics in energy detection can be accurately modeled as independent and identically distributed guassian random variables. It is a more generic method as the receivers do not need any knowledge on the primary user's signal. The signal is detected by comparing the output of the energy detector with a threshold which depends on the noise floor. The important challenge with the energy detector based sensing is the selection of the threshold for detecting primary users. The other challenges include inability to differentiate interference from primary users and noise and poor performance under low signal-to-noise ratio values.
Let the received signal be of the form,

$$y(n) = s(n) + w(n)$$

where s(n) is the signal to be detected, w(n) is the additive white Gaussian noise (AWGN) sample, and n is the sample index. Note that s(n) = 0 when there is no transmission by primary user.
The decision metric for the energy detector can be written as

$$M = \sum_{n=0}^{N} |y(n)|^2$$

where N is the size of the observation vector. The decision on the occupancy of a band can be obtained by comparing the decision metric M against a fixed threshold λ_E. This is equivalent to distinguishing between the following two hypotheses:

$$H_0 : y(n) = w(n)$$
$$H_1 : y(n) = s(n) + w(n)$$

P_D (probability of detection) and P_F (probability of false alarm) are the important factors for energy based detection which gives the information of the availability of the spectrum.

$$P_D = \Pr(M > \lambda_E | H_1)$$
$$P_F = \Pr(M > \lambda_E | H_0)$$

P_F should be kept as small as possible in order to prevent underutilization of transmission opportunities. The decision threshold λ_E can be selected for finding an optimum balance between P_D and P_F. However, this requires knowledge of noise and detected signal powers. The noise power can be estimated, but the signal power is difficult to estimate as it changes depending on ongoing transmission characteristics and the distance between the cognitive radio and primary user. In practice, the threshold is chosen to obtain a certain false alarm rate. Hence, knowledge of noise variance is sufficient for selection of a threshold.

The white noise can be modeled as a zero-mean Gaussian random variable with variance σ^w, i.e. $w(n) = N(0,\sigma^w)$. For a simplified analysis, let us model the signal term as a zero-mean Gaussian variable as well, i.e. $s(n) = N(0,\sigma^s)$. The model for s(n) is more complicated as fading should also be considered. Because of these assumptions, the decision metric follows chi-square distribution with 2N degrees of freedom χ^{2N} and hence, it can be modeled .

For energy detector, the probabilities P_F and P_D can be calculated as

$$P_F = 1 - \Gamma\left(L_f L_t, \frac{\lambda_E}{\sigma_w^2}\right),$$
$$P_D = 1 - \Gamma\left(L_f L_t, \frac{\lambda_E}{\sigma_w^2 + \sigma_s^2}\right)$$

where λ_E is the decision threshold, and $\Gamma(a,x)$ is the incomplete gamma function. In order to compare the performances for different threshold values, receiver operating characteristic (ROC) curves can be used. ROC curves allow us to explore the relationship between the sensitivity (probability of detection) and specificity (false alarm rate) of a sensing method for a variety of different thresholds, thus allowing the determination of an optimal threshold. Figure 4 shows the ROC curves for different SNR values. SNR is defined as the ratio of the primary user's signal power to noise power, i.e. SNR=σ^s/σ^w. The number of used samples is set to 15 in this figure, i.e. N = 15.

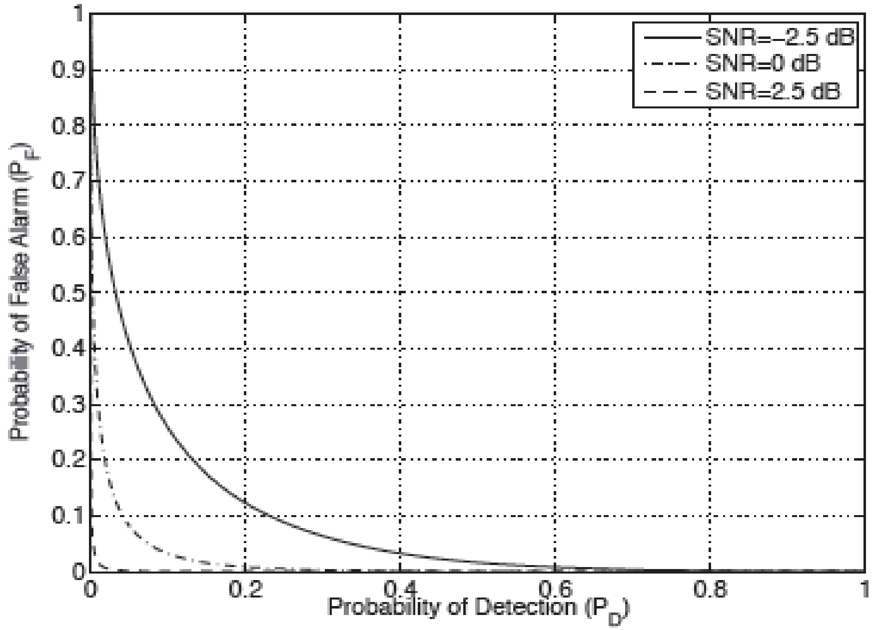

Figure 2: ROC curves for energy detector under different SNR

This figure obviously demonstrates that the execution of the limit finder increments at high SNR values. The threshold used in energy detector based sensing algorithms depends on the noise variance. Consequently, a small noise power estimation error causes significant performance loss. As a solution to this problem, noise level is estimated dynamically by separating the noise and signal subspaces utilizing numerous sign arrangement (MUSIC) algorithm. Noise variance is obtained as the smallest eigen estimation of the approaching signal's auto correlation. At that point, the assessed worth is utilized to pick the edge for fulfilling a consistent false alarm rate.

An iterative algorithm is proposed to find the decision threshold. The threshold is found iteratively to satisfy a given confidence level, i.e. probability of false alarm. Forward methods based on energy measurements are studied for unknown noise power scenarios. The proposed method adaptively estimates the noise level. Therefore, it is suitable for practical cases where noise variance is not known.

A block diagram of the energy detector is given below. The received signal r(t) can be written as r(t) = hs(t)+n(t), where s(t) is the detected signal waveform, n(t) is additive white Gaussian noise (AWGN) and h = 0 under hypothesis H0 (no PU signal present) and h = 1 under hypothesis H1 (PU signal present). First, the received signal is filtered by an ideal band pass filter with impulse response f(t) and bandwidth W to limit the noise power. The filtered signal
rf (t) = f(t)∗r(t) is squared and integrated over time T.

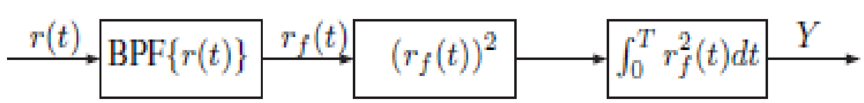

Figure 3: Block diagram of Energy detector

It is an essential and a common approach to spectrum sensing since it has moderate Computational complexities, and can be implemented in both time domain and frequency domain. To adjust the threshold of detection, energy detector requires knowledge of the power of noise in the band to be sensed. Compared with energy detection, matched filter detection and cyclostationary detection require a priori information of the PUs to operate efficiently, which is hard to realize practically since PUs differ in different situation. Energy detection is not optimal but simple to implement, so it is widely adopted. The signal is detected by comparing the output of energy detector with threshold which depends on the noise.

RESULTS AND ANALYSIS

Graphs are plotted for spectrum sensing under energy detection technique for various parameters:

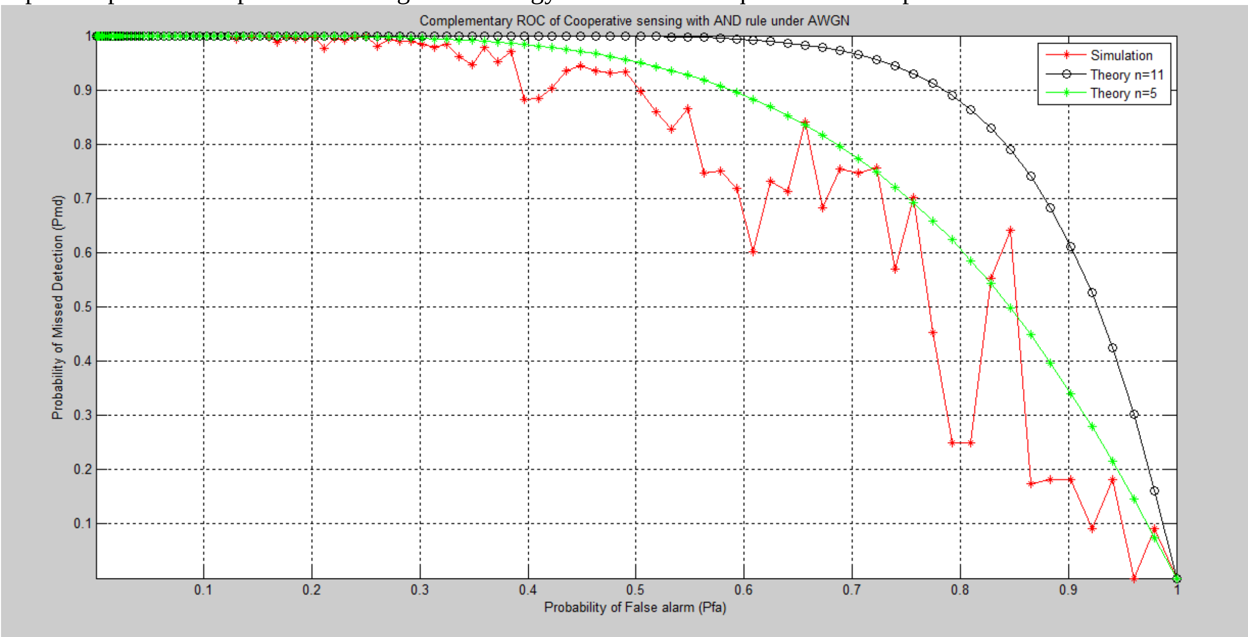

Figure 4: Probability of False alarm vs Probability of Missed Detection in Spectrum Sensing

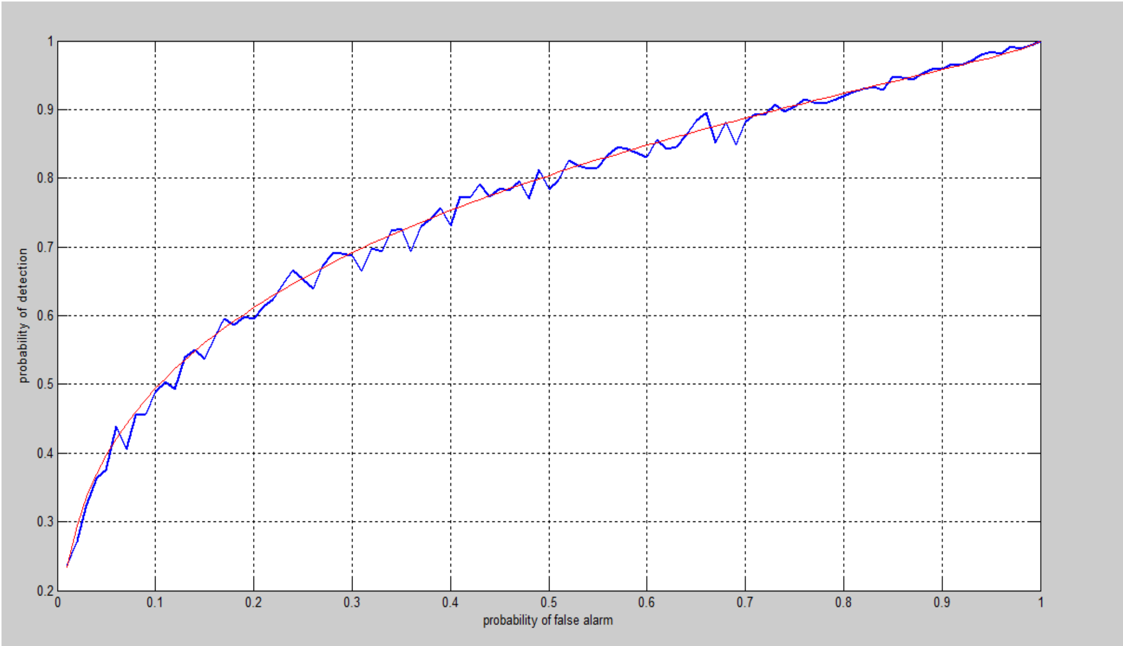

Figure 5: Probability of Detection vs Probability of False alarm

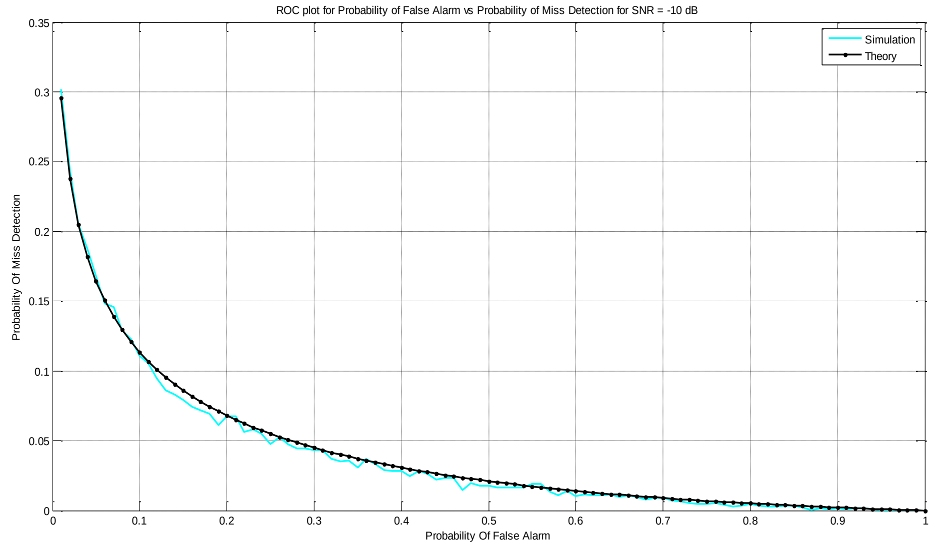

Figure 6: Probability of false alarm vs Probability of miss detection

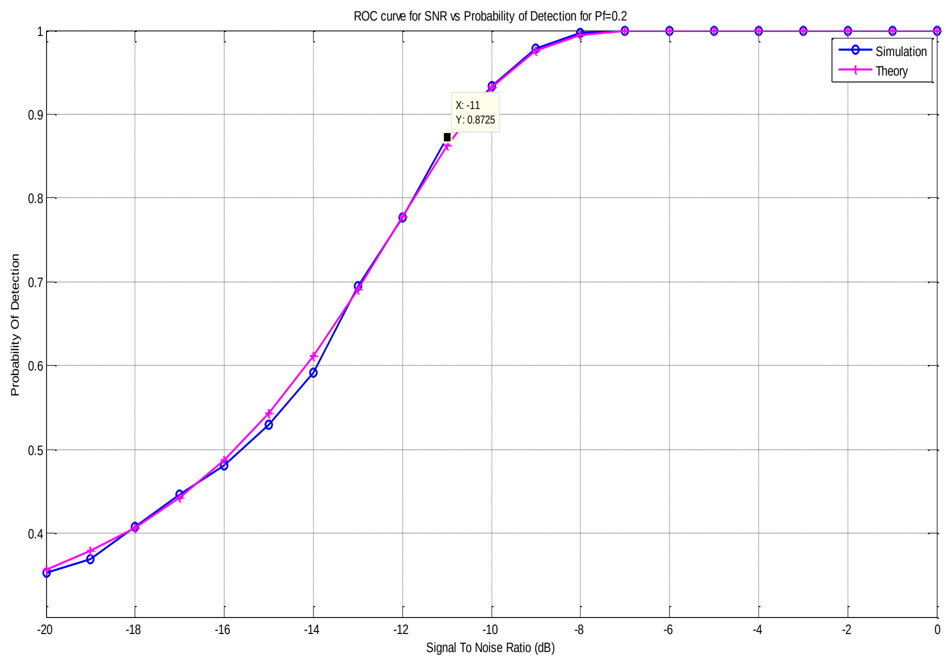

Figure 7: Signal to noise ratio vs probability of detection

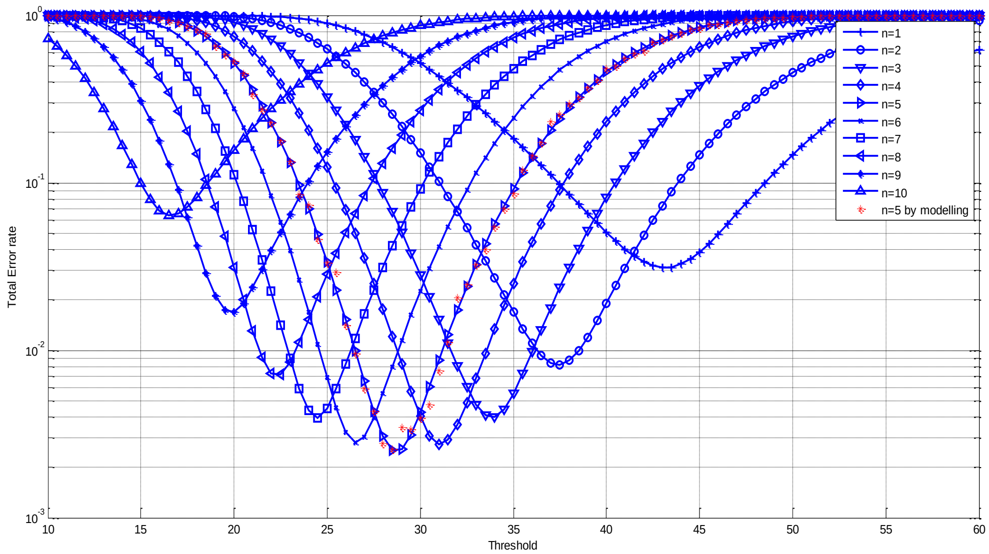

Figure 8: Threshold vs Total error rate for optimization of spectrum sensing

CONCLUSION

Thus, the range is sensed and identified utilizing radiometry (vitality indicator) and the execution of its usage is dissected through simulation. Sensing the range serves to comprehend the measure of under or un-used range accessible. This free range can be distributed to optional clients, consequently, guaranteeing greatest range usage. . Despite its practical performance limitations, energy detection has gained popularity during the last years as a spectrum sensing technique for dynamic spectrum access in cognitive radio networks. The main advantages of energy detection-based spectrum sensing are its simplicity, low computational and implementation costs as well as its ability to work irrespective of the actual signal to be detected. Since no prior knowledge is required, energy detection can be employed when the secondary receiver cannot gather sufficient information about primary user signal.

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