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DESIGN AND SIMULATION OF SMART WIRELESS DEVICES USING SCMA TECHNOLOGY

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Abstract

Recently, due to the increasing demand for wireless applications, many conditions and restrictions on their use have been put in place, including the use of available and limited radio spectrum. At the same time, the demands of massive mobile connectivity of various devices and various applications set requirements for mobile technology (5G) for the next generations. Therefore, there is a need for much higher network capacity, higher ranges of mobility, much higher performance, and much lower latency in 5G. One of 5G's possible new technology is the use of multiple access methods to enhance performance. Therefore, using a new multiple access technique called Sparse Code Multiple Access (SCMA) instead of OFDMA (4G). In addition, SCMA is a new non-orthogonal frequency domain multiple access techniques introduced which can improve the wireless radio access spectral efficiency with acceptable BER values at high loading system.

Keywords: 5G, MFD, SCMA, Spectrum Sensing, SWD.

1. Introduction

We recognize that the frequency spectrum is bounded; however, growing request of equal due to the fact for modern implementations of cell users has to lead to scarceness for accessible spectrum. The aim of grant adaptability to wireless transmission through dynamic spectrum get right of entry to as nicely as improving the use of the frequency spectrum, comes the idea of cognitive radio [1, 2]. Sparse multi-access code (SCMA) and wireless multicast noticed as two effective spectral efficiency improvement techniques.

The large growth in the wireless communications network (WCN) leads to a reduced spectrum and access to the wireless spectrum is a restricted natural resource, which is overcrowded every day. Many of the allocated frequency bands has been observed that the allocated spectrum is not fully used to the fixed spectrum distribution. The traditional method of spectrum administration is not now adaptable. To work, one license specified for each wireless operator in a confirmed frequency range. It is complicated to detect unoccupied domains to install recent offers and improve present ones. To overwhelm this status, we want to use a broad spectrum that inspires dynamic spectrum access (DSA).

A potential settlement is to utilize the "Cognitive Radio" method, is smart wireless device (SWD) system or the radio, it can feel and is perfectly aware of his functional state and can adjust work standards. This method shows promising solutions to use the spectrum to efficiently reach the frequency band. Through analysis, consideration, and learning, SWD adjusts to the surrounding medium. Conditions and employ this analysis led to decisions in the future.

There are often two levels of customers in SWD form. Firstly, authorized users are primary users (PU) and take precedence in the use of a given fixed frequency band for communications. Secondary User (SU) users are permitted to temporarily utilize frequency spectra only if they work not interfere with PU. Therefore, the possibility of sensing the inactive spectrum and the might to tentatively use the spectrum without intervening with PU are base elements of CR's success [3].

2. Background Study

We investigate the performance of implementing a sparse code multiple access (SCMA) system, which can access the wireless channel opportunistically using SWD capabilities. In fact, Zhang et al. [4] assessed NOMA use for the mmWave multicast cooperative system. On the other hand, Lv et al. [5] investigates the use of NOMA to multicast smart wireless device (SWD) networks and proposes a dynamic cooperative transmission scheme. SCMA system research focuses primarily on the design of codebooks [6-8]. The most likely candidate scheme for 5G code-domain multiple access could be sparse code multiple access. It is based on density spreading code division multiple access. It combines bits mapping and bit spreading. SCMA maps the information bits to sparse Codewords drawn from a multi-dimensional Codebook. After that, SCMA multiplexes the codewords over a set of orthogonal time/frequency resources such as circular-QAM and orthogonal frequency division multiplexing (OFDM).

Figure 1 shows SCMA's basic system model, the data coded bits are translated directly from a codebook to a codeword, which is the key difference between SCMA system models. The benefit of SCMA is its intrinsic shaping value because in constructing the multi-dimensional constellation, SCMA enjoys additional levels of freedom. Recently, it has been suggested that NOMA scheme supports massive user connectivity for the networks of the 5th generation. One of these non-orthogonal methods is SCMA with OFDM in the frequency domain. Spectrum sensing enables smart wireless device capabilities for the SCMA system applied in smart wireless device (SWD). In addition, SWD is a radio for wireless communication networks (WCN) in which either a network or a wireless node adjusts its parameters of transmission or reception depending on contact with the environment to communicate effectively without interfering with the licensed users [9] as shown in Fig. 2.

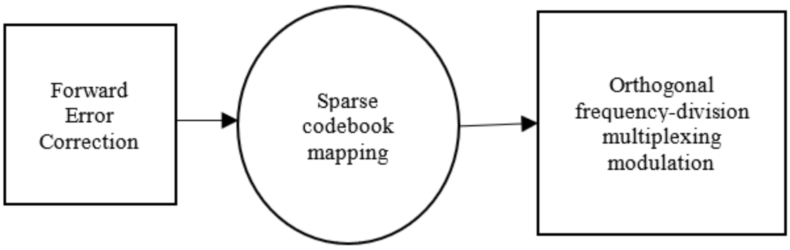


Fig. 1. Basic SCMA model.

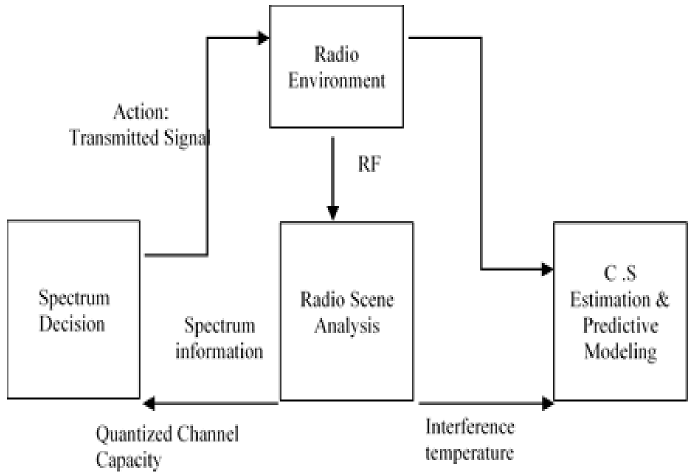


Fig. 2. Diagram of smart wireless device (SWD) [10].

Spectrum sensing is considered the main step for SWD and its aim for discovering the presence for transmissions from primary users [2]. Therefore:

- It requires fast and efficient techniques for identifying the location of the white spectrum (spectrum holes).
- The sensing technology should be clever to determine different communication technologies of the surrounding environment.
- The sensing technology should be widening the scan dimensions to fill each white spectrum.

Figure 3 shows spectrum sensing technique and the types of this technique. We will give a brief overview about non-cooperative sensing just.

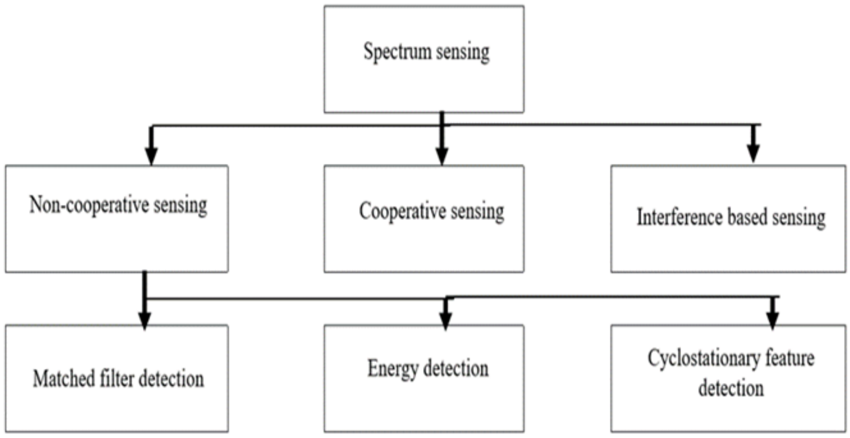


Fig. 3. Spectrum sensing techniques [2].

Matched Filter Detection (MFD) is a linear filter that increases the output S/N of the given input signal, and it is considered the better theory if the shape of the PU waveform is known and SWD is applied only in the specified PU band, it also gives the best sensor result with less sensor time [2, 11]. We can express the mathematically matched filter operation process as Eq. (1) and block diagram for (MFD) as shown in Fig. 4.

$$Y\ (n) = \sum_{k=-\infty}^{\infty} h\ (\ n - k\ )\ x\ (\ k\ ) \tag{1}$$

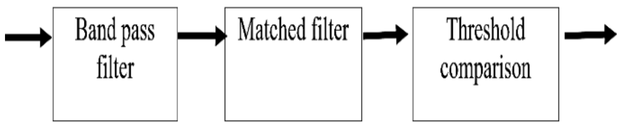


Fig. 4. Block diagram of matched filter detector (MFD) [12].

Energy detection known as non-coherent detection; it is a common way of spectrum sensing because it does not need a beforehand understanding for the PU signal. In this detection, the PU is detect based totally on the sensed energy, and the received signal is passed through BPF and band constrained signal is then built-in over a time interval as given in Fig. 5 [2, 13].

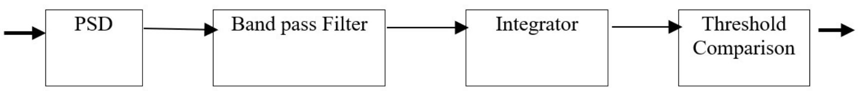


Fig. 5. Block diagram for energy detection [12].

For the interested reader, these additional topics can be found in Refs. [14-20]. The predefined threshold is compared with the time-integrated signal to identify the first signal while the hypothesis check can be expressed to determine the signal as follows [21]:

$$\text{H1} : x(n) = z(n) + f(n) \tag{2}$$

$$\text{H0} : x(n) = f(n) \tag{3}$$

Since $z(n)$ is the transmitted signal by primary users (PU); $x(n)$ is the received signal by secondary users (SU); $f(n)$ is the added white Gaussian noise (AWGN); Hypothesis H0 turns out the absence of PU; hypothesis H1 turns out the existence of PU. We can express the calculation of energy mathematically as follows:

$$\sum_{n=0}^{N} | x(n) |^2 \tag{4}$$

Now we compare energy with threshold to validate the hypothesis by the expressions follows:

$$\text{E} > \lambda : \text{H1} \tag{5}$$

$$\text{E} < \lambda : \text{H2} \tag{6}$$

Cyclostationary Feature Detection (CFD) is a periodic pattern of the transmitted signal by the primary users and is utilized to the detection of a licensed user and it is considered the most convenient over energy detector when the noise uncertainties are not acknowledged [2, 12].

3. Analysis and Results of System

Figure 6 shows a block diagram for smart wireless device (SWD) simulation, where the proposed system can be analysed through simulation in the Matlab program.

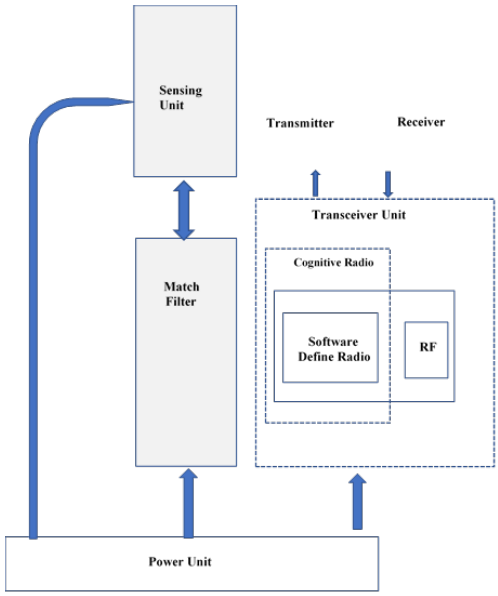


Fig. 6. Block diagram of proposed system.

Block diagram of the smart wireless device (SWD) system and Matlab program was used for the optimization of spectrum sensing in SWD network by studying the energy and the error, it will measure the time-delay and bandwidth product by a mathematical equation [22]:

$$U = {}^{N}/_{2} \tag{6}$$

$$^{S}/_{N} = 10^{{}^{S/N}/_{10}} \tag{7}$$

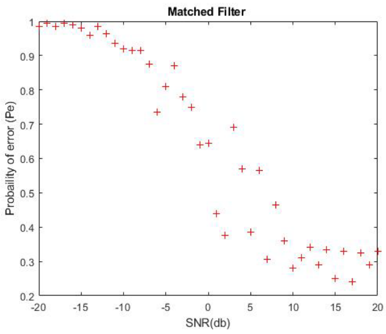
Since U is Time delay BW product and S/N is signal to noise ratio. Then it will measure the missed data detection over (AWGN) by a mathematically equation:

$$Q_d = \sum Q_d + (!\, kP_d\, (1 - P_d)^{k-1} / !\, 1^{*}!\, (k-1) \tag{8}$$

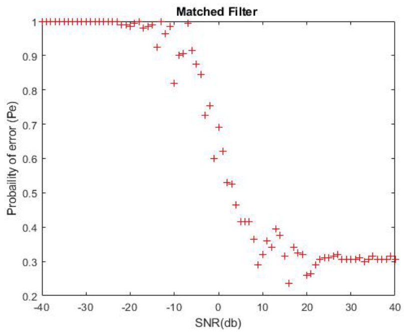
$$Q_f = \sum Q_f + (!\, k\, P_f\, (1 - P_f)^{k-1} / !\, 1^{*}!\, (k-1) \tag{9}$$

Since Q_d is generalized marcum of detection; Q_f is generalized marcum of false alarm; P_d is average problem of detection; P_f is average problem of false alarm; P_e is average problem of error.

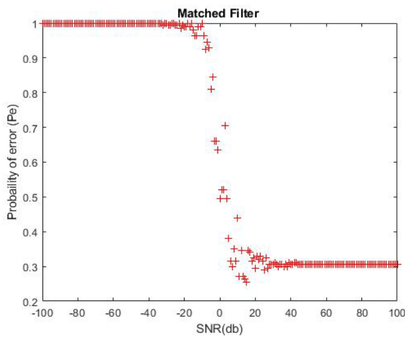
Interested readers are encouraged to refer to Ref. [23-27] for more detailed information. Energy detection probability was measured to observe the effect of the amount of noise on the signal transmission. Figure 7 shows the optimization of SNR by using matched filter detection, matched filter coefficients are given by the complex conjugated reversed signal sample. The detection after the matched filter is normally based on the power or magnitude of the signal since we need both imaginary and real parts to determine the signal completely.



(a) SNR 20dB



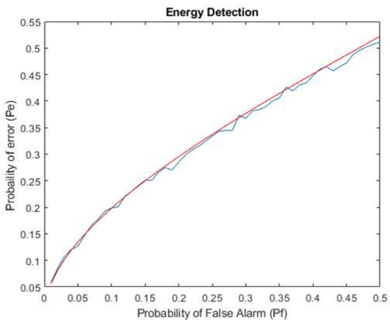
(b) SNR 40 dB



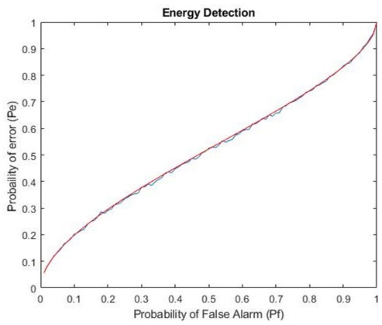
(c) SNR 40 dB

Fig. 7. Matched filter probability of detection versus SNR.

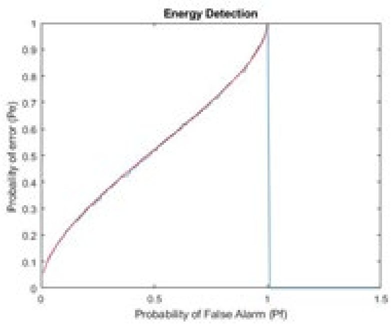
It is clear from Fig. 7(a) to (c) that P_e will be improved by increasing the SNR and the optimum value of P_e has occurred at SNR equal to about 10dB (Fig. 7(c)). The effect of using matched filter is obvious in this figure and P_e was increased abruptly reaching the best value at (10-20) dB of S/N ratio. While Fig. 8 shows the probabilities of detection with several values of SNR by using energy detection. It is clear that when the primary signal is real Gaussian signal and noise is additive white real Gaussian. Here, the threshold is available analytically and to plot probability of detection (P_d) vs. probability of false alarm (P_F). Figure 8 shows the relation of P_e against the probability of false alarm at efficient values of S/N ratio. At S/N ratio equal to 1.5 Fig. 8(c), the probability of false alarm has a small value which gives the best operation point of the system.



(a) S/N ratio equal to 0.55.



(b) S/N ratio equal to 1.00.



(c) S/N ration equal to 1.5.

Fig. 8. Performance of the proposed system by using energy detection.

The spectrum efficiency of proposed system was measured against the number of users as shown in Fig. 9. The spectrum efficiency was increased at lower values of users and the spectrum efficiency still has good value at a number of users equal to 100, which denotes the 300% load of the system.

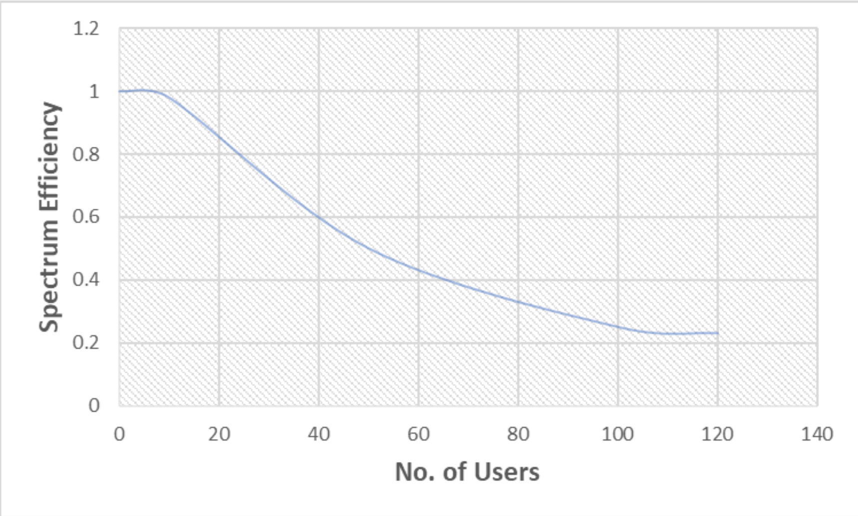


Fig. 9. Effect of number of users on achievable spectrum efficiency at specific value of SNR.

4. Conclusions

Recently and with the developments in the field of telecommunications smart wireless device (SWD) has become increasingly popular because of its spectrum sensor characteristics using SWD. Communication networks of the fifth generation can achieve high spectral efficiency through a sparse code of multiple access schemes when a large number of users attempt to transmit their data simultaneously. The spectrum is used efficiently and maintaining effective communication when the primary user does not use the spectrum it is generally believed that we lack spectrum, this means that the problem of spectrum abundance lies in spectrum management policies. As well, from the above discussions, it turns out that better technology in smart wireless device is the cyclostationary feature detector. Finally, the benefit from the spectrum sensing and energy detection is to reduce the overall error rate, and the number of users can be increased at values 300% of maximum load system.

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