Enhanced Energy Efficiency in Cognitive Radio Network Using Hybrid Spectrum Handoff

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ABSTRACT

Rapid spectrum usage in wireless networks may reduce energy efficiency, necessitating cognitive radio networks that are more energy-efficient than conventional ones. A decrease in the available spectrum's bandwidth led to the development of cognitive radio networks, which are now widely used for data transmission. In order to boost sensing efficacy and system throughput, current research ignores energy economy and handoff delay in favor of handoff decision and cooperative spectrum sensing. The energy consumption of the sensing process may be made more efficient. A threshold approach based on primary user traffic patterns is offered for spectrum mobility control. Using a threshold method, the values for probabilistic stay-and-wait and QoS handoff are calculated. In addition, a method for selecting the channel with the maximum throughput and least amount of energy consumption is developed and shown. The recommended technique reduces false alarms and miss detection while maintaining handoff delay and enhancing throughput and energy efficiency. This approach enhances the throughput, energy economy, sensor performance, and handoff time. miss-detection.

Keywords: QoS handoff; throughput; energy economy; sensor performance; and handoff time; Miss-detection.

DOI: 10.48047/ecb/2023.12.Si8.631

1. Introduction

The beneficial attribute of Cognitive Radio (CR), which is based on the dynamic spectrum, has been established in order to efficiently optimize static spectrum usage policies. One of the cutting-edge methods that effectively addresses the issue of spectrum scarcity by maximizing the spectrum is cognitive radio. A cognitive radio makes proper use of its radio settings while keeping an eye on the spectrum and its surroundings [1]. According to its official definition, cognitive radio is "a smart system that changes depending on the current environment of the spectrum, defines the spectrum hole, and communicates opportunistically via the spectrum hole with low interference to FPUs" [2]. The CSS technique is used in this research to present a SPU transmission model in CRN. Sensing and trans-mission, mobility management, and handoff decision are the three stages of the model. Spectrum handoff is the temporary capture of authorized spectrum by CRUs or SPUs. Reduced false alarms and missed detections are these functions' main objectives. Additionally, a proposed approach makes use of elements from each model phase. As a proof of concept, the model is put into action in Java utilizing the synthetic dataset and the procedures outlined in the algorithm. The remainder of the essay is structured as follows. Section 2 presents the relevant work. The SPU transmission paradigm is described in Section 3, which opens with an architectural picture of the CRN.

2. Literature Review

The execution of SS is constrained by multipath fading, shadowing, and noise uncertainty because these are the fundamental characteristics of wireless channels. The strength of the FPUs signal received at the SPUs will be great but insufficient to distinguish in situations when it is fading due to obstructions.

The foundation of non-cooperative approaches is the detection of signals emitted by the primary system. The non-cooperative methods frequently rest on the supposition that the sensing devices are aware of the primary transmission area. Therefore, in order to execute SS, the SPU should only rely on local detections and identify weak primary transmission signals.

As a result, fairness and access throughput are improved through centralized spectrum assignment. Conflict graphs control SPU interference through centralized spectrum allotment.

The central controller cannot communicate with every SPU in the network during the distributive spectrum assignment [12–15].

The advantages of MFD include the short-term requirement for a small number of available signal samples and the requirement for an acceptable detection function

[21,41].

Therefore, in areas with very low SNR, cyclostationary fac- tor detectors may be enough. To strengthen the detector's resilience, operating time estimations are taken into consideration in [47] and [48]. The "typical feature detection" capture and segmentation method refers to the elimination of data contained without cyclostationarity.

Table1: Research gap of current spectrum sensing methods in terms of throughput, energy efficiency, and handoff delay.

Spectrum SensingTechniques	AndReferences	Methods Used forSensing	Throughput	EnergyEfficiency	Handoff Delay	Advantages	Limitations
Cooperative Spectrum SensingTechnique	[6,28,29,54–56]	CooperationbetweenMultiple SPUs	Average	Average	Maximum	ReductioninThreshold. SensitivityandRequirements.	Sometimewidechannels need to bescanned.
EnergyDetection	[16–24,46–48]	SensedEnergy	Average	Average	Average	EasytoImplement.Do	IncreasedData Overhead. HighSensing Times.

Improved Improved Minimized EnergyEfficiency

EasytoImplement. —FewerSensingTime.

FPU’sPreviousInformationisnotRequired

3. Second Priority User Transmission Model(SPU)

In order to eliminate interference, it has been found that CSS performs better at identifying FPUs in the CRN. In order to increase system overhead and improve sensing time, CSS uses more energy when detecting FPUs. Researchers in wireless communication are encouraged to support energy efficiency by energy shortages and environmental norms [25].

By using the CSS approach to perceive available channels in the spectrum, this study foresaw a SPU transmission infrastructure. To reduce the amount of energy needed during the sensing process and increase energy efficiency, the CSS uses an energy detection technique. In addition, a spectrum technique based on arrival patterns is offered for the handoff choice.

CRN refers to a network that is deployed as an infrastructure network that has opportunistic access to a particular channel. Spectrum usage and energy efficiency are the major goals of enhancing overall network utilization in the CRN design. Using CRNs, users can fulfill their demands whenever and wherever they are. The Service Providers (SP) can provide (mobile) subscribers improved services. The SPs effectively distribute the CRN resources to move more packets per unit of bandwidth.

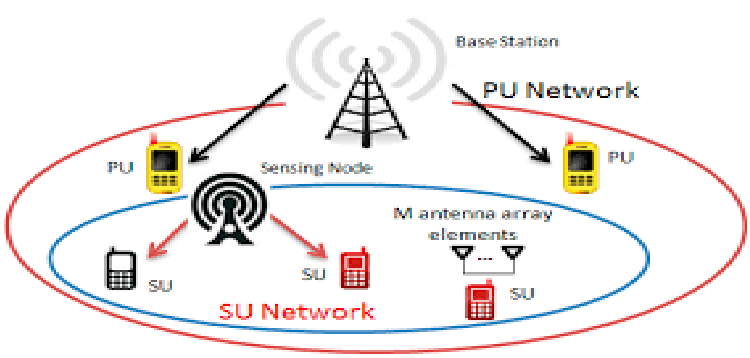

Fig.1.Cognitive Radio Network System Model

An FPU has the ability to stop the current communication being carried out by the SPU. The FPN and SPN base stations are fixed components that feature cognitive radio capabilities. The base stations represent the infrastructure side of the system and provide the following services, namely base station security management, mobility management, and management of unoccupied channels. It acts as a portal for Internet access and creates a wireless network by allowing user-to-user wireless communication. When connected to one another, several base stations in the SPN may function as repeaters.

A. Flow of proposed Model

The sensing, mobility management, and handoff decision processes in CRN are proposed to use a SPU transmission model. The available unoccupied channels are sensed using the energy detection-based CSS technique, and the hand-off decision is made using spectrum mobility management. To choose the best channel for transmission, a hybrid handoff strategy based on DSA is suggested.

The suggested SPU transmission framework is shown in Fig. 2. The planned design is broken down into the main processes of sensing and transmission, mobility management, and handoff decision, as well as being detailed in more detail in the subsections that follow.

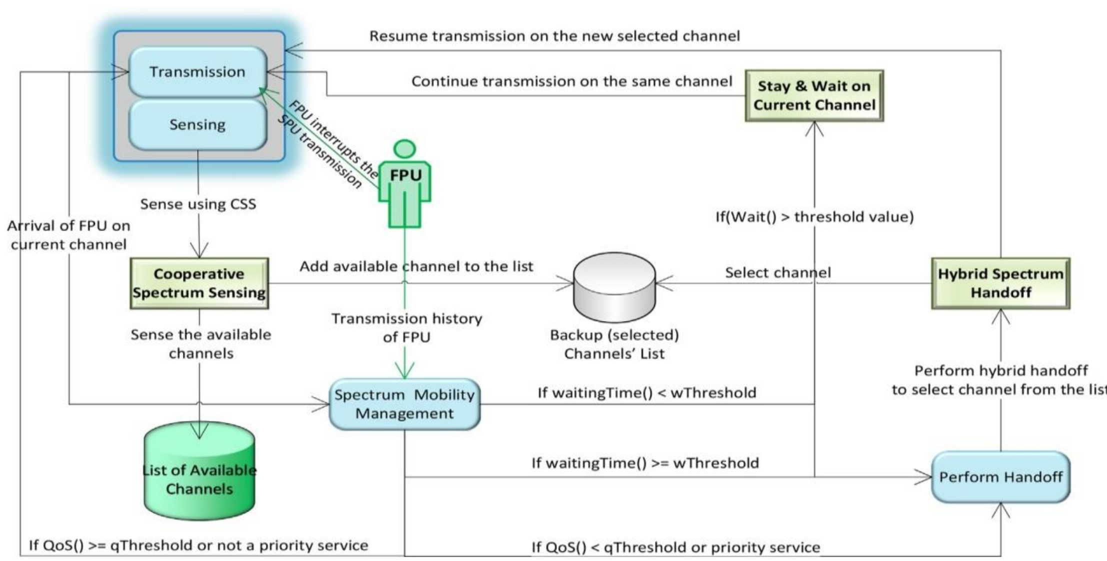

Fig.2. Transmission based on Cooperative framework Spectrum Sensing.

Additionally, CSS is regarded as a difficult task, yet it produces accurate outcomes by enhancing the sensing process. SPUs (shown in Fig. 3) continuously scan the surroundings and locate open channels by use of an energy detection system. Here is a detailed description of the energy detection scheme.

B.Energy detection Approch:

Compared to other approaches like MFD and CFD, the energy detection methodology is thought to be superior. The energy is calculated using the signal established on a fixed bandwidth and time period in the EDT technique. By connecting the stated (detected) value to the energy detector's threshold value, the energy signal is detected. Analog and digital energy detectors are the two varieties (Fig. 4) that are available. A temporary connector and a noise pre-filter are included in the analog energy detector (integrator).A square device model z2 is compatible with the noise pre-filter. The noise and noise variations are controlled by the prior filter. The received signal intensity (test statistics) matches the output produced by the integrator.

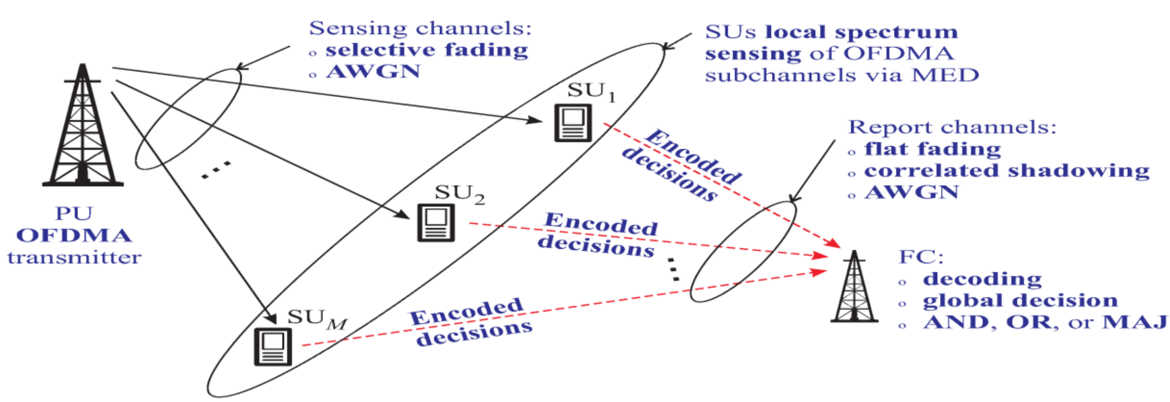

Fig.3.Spectrum Sensing Behavior

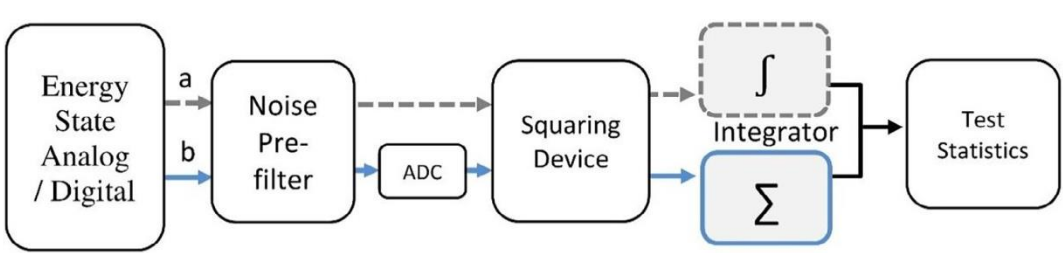

Fig.4. Block diagram of Conventional Energy Detection

Based on FPU arrival patterns, spectrum management controls SPU transmission on available channels. It facilitates coordination access and guards against channel collisions. At any given time, multiple SPUs may attempt to access the spectrum for communication, and overlapping may result. When FPUs and SPUs share a single spectrum, interference between them is eliminated via channel and power distribution.

If the FPU uses its dedicated channel for a shorter amount of time, the SPU does not decide when to hand off.The SPU's time requirements and length of stay at the current channel determine how long it waits.

By detecting numerous probabilistic quantities, such as energy and QoS, and comparing them to a fixed threshold value, this functionality can be realized (assigned explicitly).

c. Threshold optimization.

To govern mobility, a threshold approach based on key user traffic patterns is created. In mobility management, the QoS, stay and wait, and communication requirements are taken into account when managing the SPU transmission. While transmission was taking place on the present channel, the SPU routinely checked the quality of service; if it wasn't satisfactory, a handoff was made. Instead of interrupting the FPU, the SPU simply executes handoffs based on QoS. The plan determines the QoS threshold based on the channel's performance right now while taking into account the FPU traffic pattern.

d. Handoff decision

According to the mobility management procedure, SPUs may leave the present channel when FPUs or QoS regain the chosen licensed channel is not superior than the one that is now occupied. Spectrum handoff is the process of choosing a new channel. The method outlined in [54] is used to carry out the handoff.Prior to communication, SPUs detect the channel, and spectrum handoff is carried out after the event. Because channel sensing is not finished during spectrum handoff, the hybrid handoff technique has the potential to increase performance [55,56].

e. Proposed algorithm of energy-efficient model

The transmission and sensing and mobility management operations are handled by two sub-functions that are called by the primary driving function. When a connection is made, the SPU transmission begins. Step 1 involves setting the value of the set Transmitting() function to either true or false to enable transmission. The channel that the SPU is now using is stored in a variable called current Channel in step 2.Step 3 involves storing the vacant channel list in the vacant Channel List[] and initializing it with the null value.

The actual transmission and sensing for the set intervals is carried out by the transmission And Sensing() function. Current Channel and channels List[] are the inputs for this function, which outputs a list of up to four empty channels. This function also facilitates the trans- mission of a certain interval. Two time slots separate the transmission and sensing procedure interval. Only transmission occurs during the first time slot; sensing occurs during the second time slot.

4. Result and Discussion

The SPU transmission model is converted into a tool as a proof of concept. The Java programming language is used to implement the model, which is based on the technique detailed in Section 3.4. The algorithm is validated and several crucial transmission process parameters are tested using the synthetic data. Standard values were utilized to plot graphs differently after the model was run numerous times (often about 1000 times).

The proac-tive handoff is represented by the blue line, the reactive handoff is represented by the green curve, and the hybrid schemes are represented by the red line.Where the two (proactive and reactive) handoff lines intersect is the threshold value (in Fig. 5, the threshold value is 0.05). The overall service time for reactive handoff is reported as being longer than the proactive handoff when the FPU arrival rate is below the threshold value (i.e., 0.05).

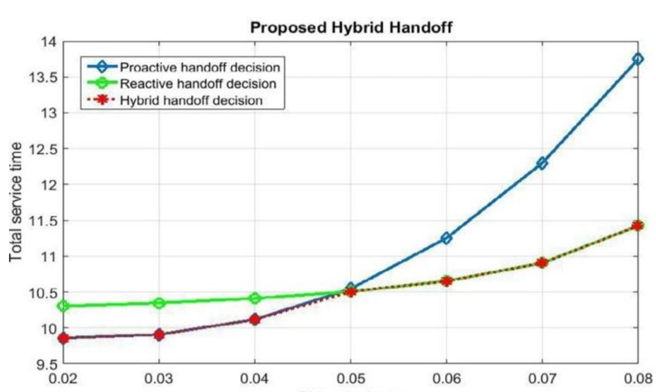

Fig.5.TheRecommended Hybrid Handoff.

Figures 6 and 7, which show the failure rate for various numbers of SPUs while taking into account false alarms and miss-detections in relation to Signal to Noise Ratios (SNR), respectively. Energy use will undoubtedly increase due to the greater sensitivity, but it will also lead to higher performance in terms of energy efficiency. As a result, it lowers the likelihood of a false alarm and doesn't waste the window of opportunity for the FPU to regain its channel.

Figure 8 compares the failure probability brought on by false alarms and missed detections in the form of a hybrid handoff. The probability values for the false alarm are shown on the x-axis, while the probability values for the missed detection are shown on the y-axis.Figures 5 and 6 show that the likelihood of a false alarm and miss (undetectable) detection is sufficiently decreased with an increased number of SPUs. Figure 8 can be used to assess the use of various SPU counts, including 2, 5, and 10, as well as an increase in the number of SPUs.

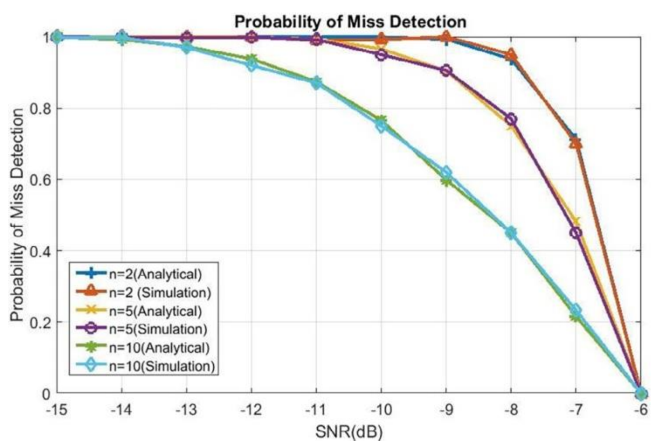

Fig.6.Probability of Miss-Detection.

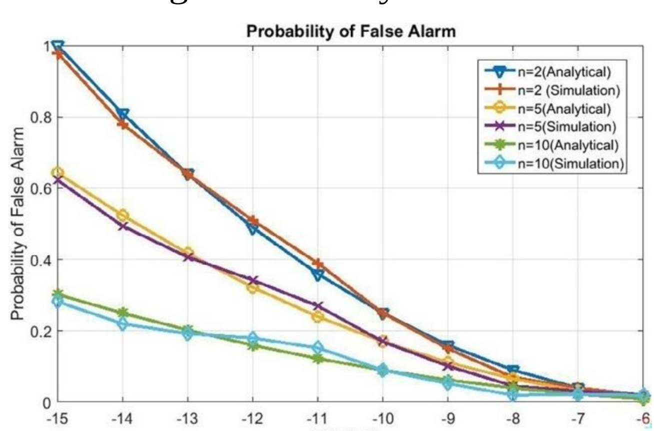

Fig.7.ProbabilityofFalseAlarm.

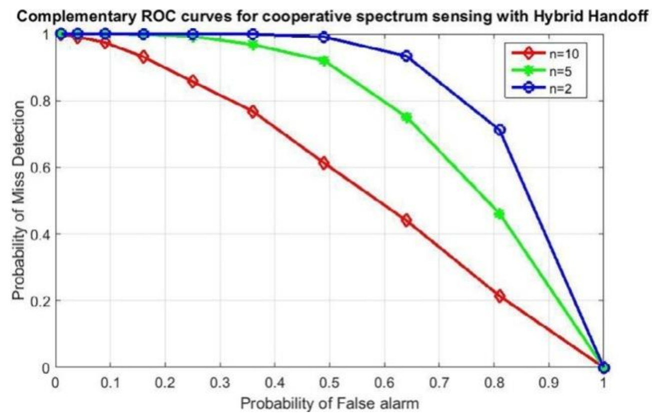

Fig. 8.Probability of Miss-DetectionandFalseAlarm using ProposedApproach.

a similar reduction in failure probabilities brought on by false alarms and missed detections.

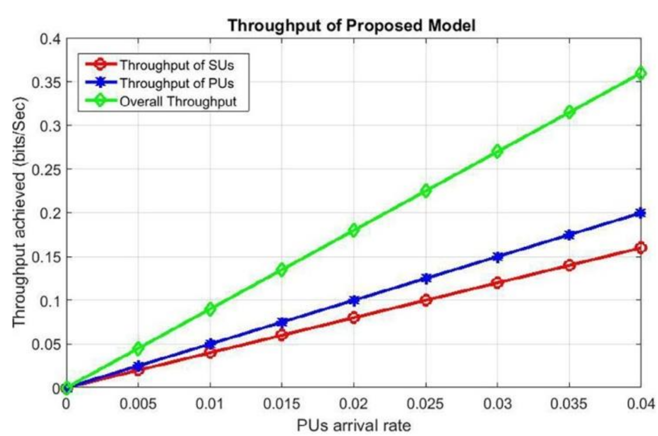

Fig.9. Through put of Proposed Framework

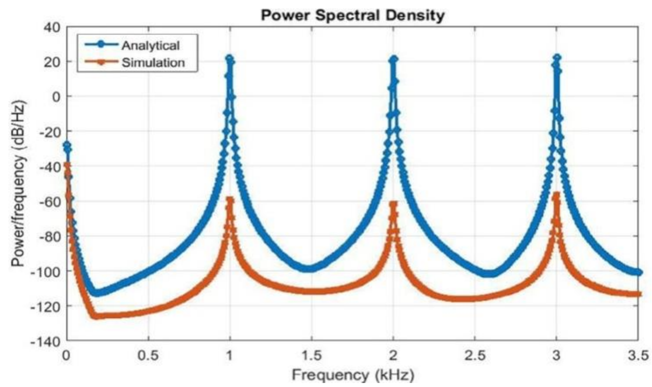

Fig.10. EnergyEfficiencyofProposedFramework.

The main advantage of using less energy is achieving throughput and energy consumption stability.

5. Conclusion and future work

A method of energy detection has been created to reduce energy usage while detecting and increase energy efficiency. A DSA-based hybrid handoff method was reinstated to choose the suitable open channel for transmission. These methods have been integrated to increase sensor efficiency and throughput while lowering energy consumption by using probabilistic values for false alarm and miss-detection. The additional unoccupied spectrums that are accessible for transmission but are not utilised, resulting in additional energy consumption, can be taken into account to improve this research. The use of numerous spectrums for transmissions by users must be encouraged in novel ways in order to achieve a high level of energy efficiency. Additionally, a means is required to distribute or transmit accurate information about channels amongst SPUs. The other SPUs consume energy by constantly detecting the occupied channel because hostile users may continue to exploit spectrum gaps and disseminate inaccurate information about them.

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