Chapter 1
Introduction

1.1 History of Communication Networks

Around 30 years ago, global communication networks emerged. The early capabilities of networks were constrained. Prior to the advent of colleges and large Information Technology (IT) corporations, Internet access was largely restricted to the academic community, and even then, speeds were slow. Wireless communications were emerging but were limited to voice conversations, were expensive, and relied on incompatible regional standards.

As time went on following 1995, service providers improved their communication infrastructure. The price of international phone calls dropped significantly. Around that time, a universal standard for wireless communications was developed. GSM, a dependable voice and message system, started it. The price of and availability of dial-up internet at home decreased. The GSM network's data transfer rates were inadequate, and mobile internet access was restricted.

The field advanced after 2000. Internet and telecommunication businesses become increasingly intertwined. DSL internet connections were significantly quicker than dial-up. Skype calling service was also attempted [1]. GPRS packet switching made mobile internet more accessible. It outperformed circuit switching for internet services.

After 2005, there was a meteoric rise in the number of people with access to the internet and mobile devices. As the speed of DSL rise and 3G networks emerged, the situation improved. High-speed data packet access was one of the protocols adopted by 3G networks (HSDPA). Faster mobile internet for surfing and emailing was one of their selling points. The cost of Smartphone's has decreased along with the cost of data plans, allowing for widespread availability. After that, earlier this decade, LTE networks began offering increased transfer rates. LTE networks provide for quick and cheap video calling and streaming. Soon, we will have access to fifth-generation (5G) networks that can transfer data at previously unimaginable speeds. To a large extent, packet switching is replacing other digital communication methods. To deploy various services and consolidate communications, they use IP.

Wider frequency ranges are required at higher rates. Mobile communication is challenging. The radio spectrum is used by a variety of regional communication devices. Spectrum for different communication protocols and standards has been allotted over time. The majority of the spectrum was already allocated, rendering the development of new wireless technologies unfeasible. Some strategies were launched to back up significant advances in wireless tech, radio systems, the Internet of Things (IoT), and machine-to-machine (M2M) communications. One potential answer is found in cognitive radio (CR).

1.2 Motivation

The wireless network's dedicated spectrum allocation distribution practice has been effective for decades. Yet, a past survey demonstrates that the quantity of wireless service providers using the available part of the spectrum has increased exponentially. Moreover, the vast majority of the spectral range is only rarely utilized.

One such new technology is cognitive radio that allows unlicensed users to make simple and efficient utilization of a previously underutilized band or sub-band of frequencies without negatively impacting primary or licensed users. To prevent unnecessary impact with current primary services, it is crucial to reliably identify the presence of primary users. The more CR learns about the PUs, the more effectively it can transmit and use the spectrum that is currently unused. Spectrum sensing for CR can be accomplished in a number of different ways, including energy detection, matching filter detection, and cyclo-stationary detection. Nonetheless, energy detection is a highly effective spectrum sensing technology because of its ease of use, minimal computing, and operational cost. Similarly, knowing the signal's primary user is not necessary for energy detection.

So far, in a real-world communication environment, extensive multi-path fading and shadow effect may significantly reduce the localized sensing efficiency of individual users. As a result, spectrum sensing performed by a single unlicensed user is inadequate. Yet, spectrum detection can be vastly enhanced by enabling numerous users to contribute individual localized sensing findings and to collaboratively determine on the licensed spectrum availability. Spectrum sensing, in the environment of cognitive radio, is also heavily impacted by the fading qualities of the transmission links. For instance, an SU may be unable to differentiate between a severely fading channel and an empty one if multi - path or shadowed is present. The first stage in figuring out the spectrum sensing needs and constructing effective CR receivers is performing a functional study of spectrum sensing then investigating possible fading mitigation solutions. As a result, research into spectrum sensing across fading channels, which most effectively represent the modern state of M2M implementations. Co-operative Sensing offers a superior solution to all of the aforementioned obstacles. One of the two basic approaches to combining data is utilized by fusion centers (FC) in CSS. There are two types of decision fusion: hard fusion scheme (HFS) and soft fusion scheme (SFS). Clusters are a useful way to organize a CR network and facilitate data fusion by separating users into manageable subsets. The administrator in charge of a group of CR users is known as the Cluster Head (CH), while the group's other users are known as member of the clusters.

This thesis explores de-centralized co-operative spectrum sensing through the framework of a clustering methodology. The developed framework is explored using a two-stage, hard fusion technique. Using a two-stage cooperative effort from the CR users, we execute the spectrum sensing on a cumulative process. The first operation is carried out only within the cluster, whereas the latter operation is carried out between different CHs. In the following chapters, we talk about how well decentralized cooperative spectrum sensing works under various fading channels.

1.3 Contribution

The contributions of this research concentrate on two forms of spectrum sensing in cognitive radio networks: cooperation using centralized mode and cooperation using decentralized mode. Both of these modes are examples of cognitive radio networks. Spectrum sensing is a significant component of CR that we have explored and researched thoroughly using energy detection-based de-centralized co-operative spectrum sensing (D_CSS) approaches. The following is a rundown of the original contributions that this work has made:

- We address a spectrum sensing framework that is based on a clustering approach for use in decentralized cooperative spectrum sensing, with the goals of improving detector performance reliability and reducing interference with the primary network.

- In the clustering approach, we set up one secondary user out of many SUs in cluster for each cluster who acts as the main administrator for that cluster. This is done to avoid the shadowing and multipath effects. We suggested a method based on the most energy, and the administrator would be chosen based on which secondary user gets the most energy from the main network.

- CSS normally uses the usual hard decision procedure to determine the existence of PU (i.e. – AND, OR). We obtained formulas for the two-stage hard decision strategy for the proposed D_CSS with clustering framework by examining this approach.

- The proposed D_CSS with a clustering framework is tested over a two-wave channel with diffuse power. The goal is to reduce the chance of missing a detection, which improves the performance of the detection.

- By getting several ROC graphs, such as SNR versus P_{md} , P_{fa} versus P_d, and SNR versus P_d, for various numbers of SU's aggregated around primary network, the effectiveness of D CSS with a clustering strategy is evaluated.

- The performance of D_CSS with clustering framework over TWDP fading channel for different values of T and it is compared with C_CSS without clustering approach over TWDP fading environment. Also compared the proposed framework results are compared with past researched methods - ED based, Evidence based CSS approach over AWGN, Rayleigh and wei-bull channel.

1.4 Thesis Organization

The purpose of this thesis work is to carry out an investigation of the performance of de-centralized co-operative spectrum sensing utilizing a clustering approach over two-wave with diffuse-power fading channel with employing a two-stage hard decision making strategy. The most important takeaways from the research are outlined in separate chapters, and an overview of each chapter along with an explanation can be found below,

In Chapter 1, a comprehensive review of the evolution of wireless communication and the growth of each subsequent generation of wireless communication is shown, together with the motivation for the research that was implemented and documented in the thesis, and the significant contributions is given.

In chapter -2, comprises of introduction to Cognitive radio, approaches for accessing the secondary spectrum, the fundamental terminologies linked with CR, the important functions of Cognitive radio by graphical representation, the basic principle about spectrum sensing, at last the applications advantages and disadvantages for the CR network's has been discussed.

In Chapter 3, Analytical model and benchmarks of the spectrum sensing are discussed. Different non-cooperative and co-operative Spectrum sensing methods operation is discussed, Where typical spectrum sensing techniques are covered in detail, as well as how localized detectors judgments are communicated to the network and merged to form global decisions in CSS approach is explained. Impacts of the different wireless communication fading channel are also presented in this chapter. At last, the several phases of literature survey are presented in systematic manner and also detailed review of previous research has been discussed.

In chapter 4, presents and discusses the proposed de-centralized co-operative spectrum sensing using clustering approach to measure the performance over two-waves with diffuse-power channel. Represented the process of clustering method is discussed with graphical representation and its flowing sequence of cluster formation. The working procedure of the de-centralized co-operative spectrum sensing using clustering approach is presented. Also, mathematical expression related to two-stage hard decision strategy has been derived from co-operative spectrum sensing.

In chapter 5, the performance of evolution of de-centralized co-operative spectrum sensing using clustering approach with two-stage hard decision strategies is analyzed using MATLAB simulations, Such as SNR Vs. missed-detection probability, false-alarm probability Vs. detection probability as well as SNR Vs. detection probability is obtained for the proposed model over TWDP fading channel. Also, the comparison analysis of such results between Centralized CSS and De-centralized CSS over two-wave with diffuse-power channel. Also, two-stage fusion strategy's results are compared with over other fading environments i.e. AWGN, Rayleigh, Rician, wei-bull channel.

In chapter 6, finally covers summary of investigation as a conclusion, future work opportunities in relevant or non-relevant methods, towards the expansion of this research have been pointed out.