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Design Spectrum Sensing Scheme a Fault Tolerant CRN Based On Cooperative

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ABSTRACT

This technique is called spectrum sensing. Spectrum sensing and estimation is the first step to implement Cognitive Radio system .We can categorize spectrum sensing techniques into direct method, which is considered as frequency domain approach, where the estimation is carried out directly from signal and indirect method, which is known as time domain approach, where the estimation is performed using autocorrelation of the signal. Another way of categorizing the spectrum sensing and estimation methods is by making group into model based parametric method and periodogram based non-parametric method. There is still there is room for researchers in this field to explore more sophisticated approaches. There are three major categories of spectrum sensing techniques; transmitter detection, receiver detection and interference temperature detection. This thesis presents a survey of techniques suggested in the literature for spectrum sensing with a performance analysis of transmitter-based detection techniques. An algorithm for minimizing sensing time has been proposed in which under high SNR values we can minimize sensing time. Its results are also reliable in comparison with other transmitter detection techniques.

INTRODUCTION

The adaptations that are performed are typically reactive, taking place after a problem has occurred. In this dissertation, we advance the idea of cognitive networks, which have the promise to remove these limitations by allowing networks to observe, act, and learn in order to optimize their performance. And thus Cognitive radio is proposed as a technology to solve the imbalance between spectrum scarcity and spectrum underutilization.

Limited in state, scope and response mechanisms, the network elements (consisting of nodes, protocol layers, policies and behaviors) are unable to make intelligent adaptations. Communication of network state information is stifled by the layered protocol architecture, making individual elements unaware of the network conditions experienced by other elements. Any response that an element may make to network stimuli can only be made inside of its limited scope.

Characteristics of Cognitive Radios

Cognitive radio dynamically selects the frequency of operation and also dynamically adjusts its transmitter parameters. The main characteristics of cognitive radios are

- Cognitive Capabilities
- Reconfigurability.

Cognitive Capability

Cognitive capability refers to the ability of radio to sniff or sense information from its environment and perform real time interaction with it. The cognitive capability can be explained with the help of three characteristics; Spectrum Sensing, Spectrum Analysis and Spectrum Decision. The spectrum sensing performs the task of monitoring and detection of spectrum holes. The spectrum analysis will estimate the characteristic of detected spectrum hole. In the spectrum decision, the appropriate spectrum is selected by determine the parameters like data rate, transmission mode etc.

Reconfigurability

Reconfigurability refers to the ability of radio that allows the cognitive radio to adjust its parameters like link, operating frequency, modulation and transmission power at run time without any modifications in the hardware components. In other words Reconfigurability of CR is SDR. Doing so we dynamically change all the layers of communication as shown in Figure 1. We can use different technologies depending on their spectrum availability with the same hardware.

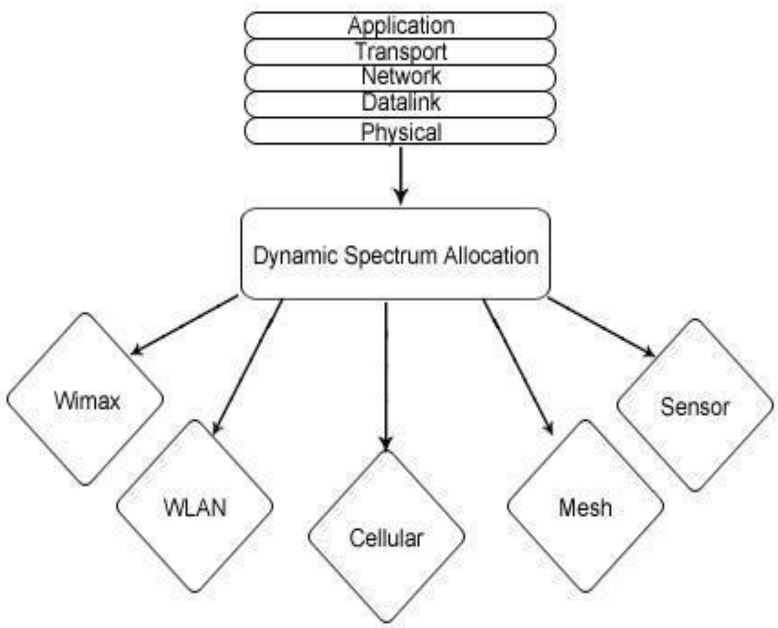

Figure 1. Dynamic changes in all Layers

The components of the Cognitive Radio network architecture, as shown in Figure 1., can be classified in two groups such as the primary network and the CR network. The basic elements of the primary and the CR network are defined as follows:

LITERATURE REVIEW

A natural place to begin a discussion of the roots of Cognitive Radio is with complexity. It has found its way into mainstream literature by offering tantalizing parallels between seemingly disjointed areas and providing an underlying structure to seemingly random phenomena [5, 6]. Complexity research has been driven by the failure of traditional reductionist approaches of science to explain behaviours of large, diverse and interconnected systems [7]. Systems of interest to complexity research typically are composed of many interacting parts, each with behaviours simpler than that of the system. Out of these simple individual behaviours, system behaviours that are on the edge between order and chaos are observed. Examples of systems exhibiting various degrees of complexity are economic markets, biological populations, and social networks.

Barrett et al. [8] describe these systems as Biological, Information, Social, and Technical (BIST). By examining these systems from a more holistic point of view, complexity attempts to provide an explanation for the behaviours of these systems. In trying to describe complexity, many characteristics of complex systems have been identified. Size of the system [9] is a commonly cited distinguishing feature. Interaction-based systems (as opposed to algorithm-based systems) are given as another characteristic. Wegner [10] argues that interactions are a more powerful paradigm than algorithms, since algorithms cannot take into account time or the interaction events that occur during computation. For this reason, he claims that interaction-machine behaviour cannot be reduced to Turing machine behaviour. Whether or not his postulate is correct, the idea of interaction is a critical aspect to differentiating a complex system. Another idea used to describe complexity is that complexity is a mix of order and disorder [11]. Perhaps the measure of a complex system is a function of the capacity of the observer to understand and decode the source of order in a system.

Wireless Networks

a natural place to begin this discussion is with wireless networks. Unlike wired networks, in which data transmitted between nodes on separate wires is isolated from interactions, wireless systems all share a common medium and devices may conflict with any other device in their transmission range. Effectively, there is one physical medium, rather than the many that may exist in a wired network, greatly expanding the number of potential interactions.

Wireless networking technology has become a hotbed of research activity and development in the last decade. With the advent of standards such as IEEE 802.11, Bluetooth, WiMAX, CDMA2000 and Universal Mobile Telecommunications System (UMTS), high data rate wireless networks have became real-world systems. However, the next generation of wireless technologies promises levels of complexity well beyond that of the current generation [12].

With the decreasing cost and increasing power of analog to digital converters and computer processors, a new kind of radio that performs signal processing in the digital rather than analog domain has become feasible. These radios, known as Software Defined Radio (SDR), move most of the RF and Intermediate Frequency (IF) functionality, including waveform synthesis, into the digital (rather than the analog) domain, allowing for great flexibility in the modes of radio operation (called personalities). The initial applications for SDR were almost entirely military in nature, and current research is still driven by the needs of military interoperability. The Joint Tactical Radio System (JTRS) is currently the focus of SDR for military applications. However, there is increasing interest in using SDR technology in commercial applications.

The flexibility of SDRs also comes with a cost. Whereas hardware defined radios have a fixed number states they can operate in, software defined radios have a practically limitless number of operating states. This increase in state space makes it possible to optimize a radio connection for many different goals; where there once was one possible mode of operation, now there might be many, each with its own strengths and weaknesses. A network of SDRs will only increase the size of the state space. The idea of CR was developed to address the difficulty in determining and achieving the best mode of operation in an SDR.

Matched Filter Detection

A matched filter is a linear filter designed to provide the maximum signal-to noise ratio at its output for a given transmitted waveform [18]. Figure 2. depicts the block diagram of matched filter. The signal received by CR is input to matched filter which is r (t) = s (t) + n (t). The matched filter convolves the r (t) with h (t) where h (t) = s (T-t + τ). Finally the output of matched filter is compared with a threshold λ to decide whether the primary user is present or not.

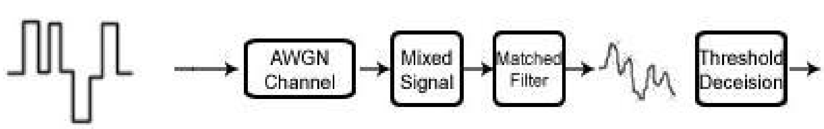

Figure 2. Block Diagram of Matched Filter

A Matched filter is an optimal detector in an AWGN channel if the waveform of primary user is previously known by CR. It means that CR should have knowledge about the waveform of primary user such as modulation type and order, the pulse shape and the packet format. So if CR doesn't have this type of prior information then it's difficult to detect the primary user. We can still use Matched Filter Detection because in most of the communication networks we can achieve this coherency by introducing pilots, preambles, synchronization word or spreading codes in the waveform of primary users. Still there are limitations in matched filter because each CR should have the information of all the primary users present in the radio environment. Advantage of matched filter is that it takes less time for high processing gain. However major drawback of Matched Filter is that a CR would need a dedicated receiver for every primary user class

COGNITIVE RADIO

Defining Cognitive Radio

The term of "Cognitive radio" was used by J. Mitola III, "Cognitive radio: making software radios more personal," in Personal Communications, IEEE, vol.6, no.4, pp.13-18, August, 1999". "A radio that employs model based reasoning to achieve a specified level of competence in radio-related domains."

The paper described that cognitive radio extends the software radio with radio-domain model-based reasoning about set of RF bands as air interfaces, protocols, and spatial and temporal patterns that moderate the use of the radio spectrum. Tautologically, a cognitive radio could be defined as “A radio that is cognitive,” or paraphrasing Descartes, “Cogitat, ergo est cognitive radio” (It thinks, therefore it’s a cognitive radio). Indeed, many researchers and public officials agree that upgrading a software radio’s control processes will add significant value to software radio, there is currently some disagreement over how much “cognition” is needed which results in disagreement over the precise definition of a cognitive radio.

The following provides some of the more prominently offered definitions of cognitive radio. However, in his recent popularly cited paper that surveyed the state of cognitive radio, Simon Haykin defines a cognitive radio as.

“An intelligent wireless communication system that is aware of its surrounding environment (i.e., outside world), and uses the methodology of understanding-by-building to learn from the environment and adapt its internal states to statistical variations in the incoming RF stimuli by making corresponding changes in certain operating parameters (e.g., transmit-power, carrier frequency, and modulation strategy) in real-time, with two primary objectives in mind:

- Highly reliable communications whenever and wherever needed;
- Efficient utilization of the radio spectrum.

Coming from a background where regulations focus on the operation of transmitters, the FCC has defined a cognitive radio as [25]:

“A radio that can change its transmitter parameters based on interaction with the environment in which it operates.”

Meanwhile, the other primary spectrum regulatory body in the US, the NTIA [26], adopted the following definition of cognitive radio that focuses on some of the applications of cognitive radio:

“A radio or system that senses its operational electromagnetic environment and can dynamically and autonomously adjust its radio operating parameters to modify system operation, such as maximize throughput, mitigate interference, facilitate interoperability, and access secondary markets.”

The international spectrum regulatory community in the context of the ITU is currently working towards a definition of cognitive radio that focuses on capabilities as follows:

“A radio or system that senses and is aware of its operational environment and can dynamically and autonomously adjust its radio operating parameters accordingly.”

While aiding the FCC in its efforts to define cognitive radio, IEEE USA offered the following definition [27]:

“A radio frequency transmitter/receiver that is designed to intelligently detect whether a particular segment of the radio spectrum is currently in use, and to jump into (and out of, as necessary) the temporarily-unused spectrum very rapidly, without interfering with the transmissions of other authorized users.”

The broader IEEE tasked the IEEE 1900.1 group to define cognitive radio which has the following working definition [40] [IEEE 1900.1]:

“A type of radio that can sense and autonomously reason about its environment and adapt accordingly. This radio could employ knowledge representation, automated reasoning and machine learning mechanisms in establishing, conducting, or terminating communication or networking functions with other radios. Cognitive radios can be trained to dynamically and autonomously adjust its operating parameters.”

Likewise, the SDR Forum participated in the FCC’s efforts to define cognitive radio and has established two groups focused on cognitive radio. The Cognitive Radio Working Group focused on identifying enabling technologies uses the following definition:

While it appears to be unlikely that there will be a harmonization of these definitions in the near future, an examination of the salient functionalities of these definitions, as summarized in Table 3.1, reveals some commonalities among these definitions. First, all of these definitions assume that cognition will be implemented as a control process, presumably as part of a software defined radio. Second, all of the definitions at least imply some capability of autonomous operation.

Finally, the following are some general capabilities found in all of the definitions:

- **Observation** – whether directly or indirectly, the radio is capable of acquiring information about its operating environment.

- **Adaptability** – the radio is capable of changing its waveform.

- **Intelligence** – the radio is capable of applying information towards a purposeful goal.

Table 1: cognitive radio definition matrix

Definer	Adapts (Intelligently)	Autonomous	Can sense Environment	Transmitter	Receiver	"Aware" Environment	Goal Driven	Learn the Environment	"Aware" Capabilities	Negotiate Waveforms	No interference
FCC	•	•	•	•							
Haykin	•	•	•	•	•	•	•	•			
IEEE 1900.1	•	•	•	•	•						
IEEE USA	•	•	•	•	•	•					•
ITU-R	•	•	•	•	•	•					
Mitola	•	•	•	•	•	•	•	•	•	•	
NTIA	•	•	•	•	•	•	•				
SDRF CRWG	•	•	•	•	•		•				
SDRF SIG	•	•	•	•	•	•	•	•	•		
VT CRWG	•	•	•	•	•	•	•	•	•		

Note that this definition of intelligence (Intelligence as defined by [28] as "The capacity to acquire and apply knowledge, especially toward a **purposeful goal**." The definition for intelligence as applied to cognitive radio differs only in that the acquisition of knowledge has been subsumed into the observation process) implies that even those definitions that do not explicitly mention a goal (or provide a specific goal such as performance) still implicitly require the existence of some goal for intelligent adaptation. By using only these common features of all these definition we arrive at the definition of cognitive radio given in.

CONCLUSION

This research was aimed towards the detection of primary user's waveform in cognitive radio networks and develops a fault tolerant cognitive radio network. The primary requirement of a spectrum sensing system is its real time processing and decision making. The proposed methodology has been implemented on PC and requires MATLAB support for simulation. Sensing Time, Detection Sensitivity and ease of implementation are considered for optimization in the spectrum sensing techniques. Minimizing sensing time algorithm and improving reliability is proposed which gives very good results at high

SNR values. Moreover for actual implementation, the technique can be implemented on real time processing hardware. Finally it is concluded that detection technique has an SNR threshold below which it will fail to operate robustly. Performance of spectrum sensing techniques limits due to uncertainty in the noise level.

FUTURE WORK

Through reviewing a number of advanced sensing techniques, we were able to reach a conclusion that further investigations are needed for 'Intermediate Solutions' in the multiple sensing nodes cooperation category.

- When developing more practical parameter estimation techniques, it might be possible to create a realizable sensing scheme which can closely achieve the optimum performance.
- Impacts on performances on our method in fading environments need to be studied in future work.
- Another area for research is cross layer communication in which spectrum sensing and higher layer functionalities can help in improving quality of service (QoS).
- We would like to investigate this aspect of cognitive radio by analyzing the system from the point of the primary user.

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