COGNITIVE RADIO NETWORKS: ISSUES AND CHARACTERIZATION OF SENSING ENHANCEMENT AND NETWORK ARCHITECTURES

by

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To my loving parents,

Sujatha and Chandran

and

My pillar of support

Harisree

Certificate

This is to certify that the thesis entitled **COGNITIVE RADIO NETWORKS: ISSUES AND CHARACTERIZATION OF SENSING ENHANCEMENT AND NETWORK ARCHITECTURES** being submitted by **Anoop C. Nair** for the award of the degree of **Doctor of Philosophy** to the Department of Electrical Engineering, Indian Institute of Technology Delhi, is a record of bonafide work done by him under my supervision and guidance. In my opinion, the thesis has reached the standards fulfilling the requirements of the regulations relating to the degree. The matter embodied in this thesis has not been submitted to any other University or Institute for the award of any degree or diploma

31 : 12 : 2012

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Abstract

Cognitive radio has evolved as the technology to opportunistically use the primary user spectrum during the absence of primary users. The key ability of a cognitive radio is to sense the spectrum for availability of spectrum opportunities. This thesis investigates spectrum sensing in cognitive radio networks. First, spectrum sensing is considered as a sequential detection problem. The complex likelihood ratio formulation of sequential probability ratio test (SPRT) is reduced to an energy detector approximation. Quantization errors are included in the design of SPRT/Truncated SPRTS. Quantization corrected TSPRT with good error performance even with low resolution quantizers is presented.

Quantization is one of the main power consuming blocks of spectrum sensing. Quantization for spectrum detection is presented as a hybrid of low SNR and high SNR quantizer. Hybrid quantizers with the ability to selectively switch the mode of operation based on the signal strength is proposed. To reuse a low resolution quantizer for high resolution operation dynamic range expanding functions are explored. The inverse law processor is established as the best realizable candidate and an analog front end with the $\frac{1}{x}$ functionality is designed and fabricated. It is tested with the quantization corrected TSPRT and established to provide very good error performance in detection

Sensing is an unavoidable overhead for cognitive radio communication. The energy consumption of sensing is simultaneously approached at circuit and network level to maximize the benefits. A power consumption model is presented for the CR transceiver and the signal detection parameters are related to the model. The low power circuit technique of dynamic frequency and voltage scaling is applied proportional to the number of bands being sensed in a sense interval. An energy optimal "sense as much as needed" approach is proposed at the network level to address the energy consumption. The energy optimal number of spectrum holes to be sensed in each cycle to service a total demand over a total interval is derived. The number of channels to be sensed and the channel senssing order to support the energy aware scheme is proposed.

Adaptively tracking the variation of primary usage is necessary to maintain a high QoS in the CR network. A sensing protocol inspired from social foraging in bee colonies is proposed to adapt to spatial and temporal changes in the primary user statistics. The protocol is analyzed using a flow based model. The protocol is ideally suited for distributed networks with no coordinating central manager. This Beesense protocol is evaluated as sensing scheme for a standard distributed CR network. In addition a sensor assisted topology, wherein an underlay network of sensors will perform the sensing and support the distributed CR in proposed. By detaching the sensing task from the CR and ensuring spatial coverage of the sensor network a significant improvement in the number of serviced request and the serviced bandwidth is exhibited.

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