Recent measurements on radio spectrum usage have revealed the abundance of under-utilized bands of spectrum that belong to licensed users. This necessitated the paradigm shift from static to dynamic spectrum access. Cognitive radio based secondary networks that utilize such unused spectrum holes in the licensed band, have been proposed as a possible solution to the spectrum crisis. The idea is to detect times when a particular licensed band is unused and use it for transmission without causing interference to the licensed user. We argue that prior knowledge about occupancy of such bands and the corresponding achievable performance metrics can potentially help secondary networks to devise effective strategies to improve utilization.

In this work, we use Shepard's method of interpolation to create a spectrum map that provides a spatial distribution of spectrum usage over a region of interest. It is achieved by intelligently fusing the spectrum usage reports shared by the secondary nodes at various locations. The obtained spectrum map is a continuous and differential 2-dimension distribution function in space. With the spectrum usage distribution known, we show how different radio spectrum and network performance metrics like channel capacity, secondary network throughput, spectral efficiency, and bit error rate can be estimated. We show the applicability of the spectrum map in solving the intra-cell channel allocation problem in centralized cognitive radio networks, such as IEEE 802.22. We propose a channel allocation scheme where the base station allocates interference free channels to the consumer premise equipments (CPE) using the spectrum map that it creates by fusing the spectrum usage information shared by some CPEs. The most suitable CPEs for information sharing are chosen on a dynamic basis using an iterative clustering algorithm. Next, we present a contention based media access control (MAC) protocol for distributed cognitive radio network. The unlicensed secondary users contend among themselves over a common control channel. Winners of the contention get to access the available channels ensuring high utilization and minimum collision with primary incumbent. Last, we propose a multi-channel, multi-hop routing protocol with secondary transmission power control. The spectrum map, created and maintained by a set of sensors, acts as the basis of finding the best route for every source destination pair. The proposed routing protocol ensures primary receiver protection and maximizes achievable link capacity.

Through simulation experiments we show the correctness of the prediction model and how it can be used by secondary networks for strategic positioning of secondary transmitter-receiver pairs and selecting the best candidate channels. The simulation model mimics realistic distribution of TV stations for urban and non-urban areas. Results validate the nature and accuracy of estimation, prediction of performance metrics, and efficiency of the allocation process in an IEEE 802.22 network. Results for the proposed MAC protocol show high channel utilization with primary quality of service degradation within a tolerable limit. Performance evaluation of the proposed routing scheme reveals that it ensures primary receiver protection through secondary power control and maximizes route capacity.
Approved for distribution by Dr. Mainak Chatterjee, Committee Chair, on January 1, 2014.

The public is welcome to attend.