Spatio-Temporal Models and Entropy Rate of Spectral Occupancy

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Abstract –

In this paper we use measurements and models of spatio-temporal spectral occupancy to provide insight into the control requirements in cognitive radio networks. Operating a secondary wireless network on a non-interfering basis requires sensing and detection. Collaborative or cooperative sensing is a promising method for avoiding hidden terminal problems and reducing the effects of shadow fading [Ghasemi 2005, Mishra 2006, Cabric 2006]. In cooperative sensing, multiple nodes across space sense spectral occupancy and share data over a control channel. This communication adds overhead to the cognitive radio network, as measured by the bit rate of the control channel. This paper will relate experimental and analytical methods to quantify the overhead. To the authors' knowledge, the quantification of the overhead has not yet been addressed.

In reported studies, the control overhead would increase with an increase in the number of collaborating spectrum sensors, and with a decrease in the latency requirement. However, the spectral occupancy in a given band is a spatially and temporally varying random process which has an information rate quantified by its entropy rate. The control channel, given appropriate distributed source coding, could achieve bit rate close to the entropy rate regardless of the density of sensors or latency requirement. Our aim in this paper is to experimentally validate a random process model for spatio-temporal spectral occupancy in a given band and then to use this model to calculate an entropy rate for the process.

The higher the temporal and spatial variability of the primary usage of the band, the higher the control requirements for the cognitive radio network will be. This paper provides a quantitative measure of the control requirements. The results directly impact the design of the collaborative sensing control channel, and indirectly indicate which bands may be too spatially and temporally variable to be efficiently used by the cognitive radio network.

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