Abstract

With the advent of fifth generation and beyond (5G+ and 6G) networks and Internet of Things (IoT) communications, the demand for increased wireless connectivity has increased many-fold. Realizing that allocating more from the finite available spectrum can only serve as a temporary fix, regulatory bodies and the research community have started to explore increasing the spectral efficiency of the already allocated frequency bands. At the same time, developing technologies that also overcome the poor economies of scale associated with deployments in sparsely populated rural areas is essential to provide ubiquitous access.

The lower end of the UHF band is particularly attractive for such technologies owing to its excellent propagation and penetration characteristics. This enables wider coverage while requiring smaller amounts of infrastructure. So far, the UHF bands have primarily been used by television (TV) and radio services. Regulatory bodies worldwide are rapidly realizing the need to open up this part of the spectrum for opportunistic access by secondary networks.

Any opportunistic use of any actively used spectrum band risks disrupting the incumbent network's operation by causing excessive signal interference. Owing to this, standards like IEEE 802.11af, IEEE 802.22 Wireless Regional Area Network (WRAN) and Long-Term Evolution in Unlicensed Spectrum (LTE-U) have been developed to steer clear of the regions referred to as TV Black Spaces (TVBS) and TV Gray Spaces (TVGS) where an incumbent is transmitting, and claim the TV White Spaces (TVWS) that are found to exist in the TV bands. As a DTV network coverages span tens of kilometers, such interference avoidance based deployment renders a huge geographical region unserviceable by the secondary networks. However, an interference management based intelligent and agile secondary network that can operate within the varying interference margins within the TVBS would be able to overcome this lacuna.

Motivated by the above observations, this dissertation explores the problem of deploying such an interference managing secondary network in the TVBS and TVGS areas. The first part of the dissertation lays the groundwork for deploying secondary networks in co-channel modes with an ongoing DTV broadcast by validating the technical feasibility of the approach. To this end, the interference caused by a secondary orthogonal frequency division multiplexing (OFDM) network on the reception of the DTV broadcast at a DTV receiver is analytically quantified and verified experimentally. A framework is then pro-

posed to manage the interference caused by secondary transmission at a DTV receiver by varying the amount of its temporal and spectral overlap with the DTV signal.

Owing to the unidirectional nature of DTV broadcast, the biggest challenge of utilizing an active TV channel is to detect the presence of active DTV receivers, which act as hidden nodes. While some new standards, such as ATSC 3.0, are evolving to cater to an interactive TV experience requirement by making optional provisions for feedback via an OTA channel, it will take time before the technology gains widespread adoption. For regions that continue to work with the legacy DTV network, the second part of the dissertation explores a method to work around the issue of hidden nodes with minimal or no changes in the existing DTV networks. As no direct feedback method from the DTV receivers is available, the problem is broken into two steps: estimating the locations of active DTV receivers and finding the signal conditions and interference impact at those DTV receivers.

Finally, the paradigm of the next-generation ATSC 3.0 DTV network where feedback could be made available is considered in the third part of the dissertation. While the problems of localization and obtaining the interference state still remain the same, the availability of some feedback on the Dedicated Return Channel (DRC) of the ATSC 3.0 network allows the use of novel techniques to maximize the coexistence opportunity. Thus, a method to harness the feedback signals from the DTV receivers for localization is proposed. With the DTV receivers now unhidden, an online learning algorithm is proposed for managing the interference at the DTV receivers. This enables the co-channel coexistence of the secondary networks with an active DTV broadcast in a ubiquitous manner.