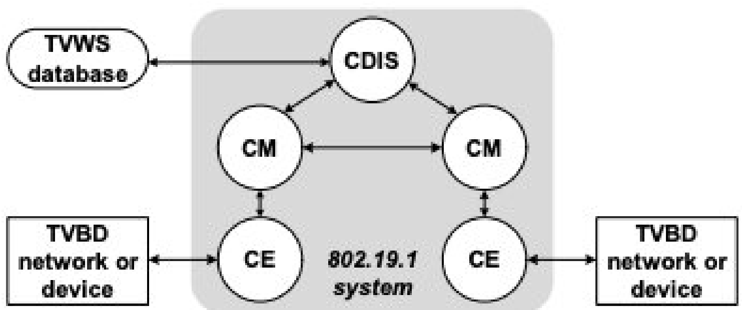
An architecture to enable the collaborative coexistence of cognitive radio networks in TVWS

February 27 2019, by Ingrid Fadelli



IEEE 802.19.1 system architecture. Credit: Bian et al.

A team of researchers at Yale University, Virginia Tech, Temple University and Peking University has recently developed a new approach to enable the collaborative coexistence of cognitive radio (CR) networks over TV white space (TVWS). The term TVWS refers to unused TV channels in between active channels in the VHF and UHF spectra. These unused channels, also known as 'buffer channels,' were originally placed between active channels to minimize broadcasting interference.

"TVWS has the potential of providing significant bandwidth in frequencies that have very favorable propagation characteristics (i.e.

long transmission ranges and superior capability of penetrating objects)," the researchers wrote in their paper, pre-published on arXiv. "In the U.S., United Kingdom and other countries, changes in the regulatory rules have been made or are being amended to open up the TVWS for opportunistic operations of unlicensed (or secondary) users on a non-interference basis to licensed users (a.k.a. incumbent or primary users)."

In light of the upcoming regulations associated with TVWS use, industry stakeholders have been trying to develop standards that could enable the use of TVWS by leveraging CR technology. CR is a form of wireless communication that can be programmed and configured dynamically in order to detect vacant communication channels nearby and optimize the use of available radio frequency (RF) spectrum.

All newly devised standards rely on CR technology to overcome interference problems between networks. The coexistence of secondary wireless networks in TVWS can be grouped into two broad categories: heterogeneous and homogeneous coexistence. The former entails the coexistence of networks that employ different wireless technologies (e.g. wifi and bluetooth), while the latter the coexistence of networks that use the same wireless technology.

In addition, coexistence schemes can either be non-collaborative or collaborative. A non-collaborative scheme is employed when there is no way to coordinate coexisting networks. A collaborative scheme, on the other hand, can be employed in instances where coexisting networks can directly coordinate their operations. Although non-collaborative coexistence schemes are cheaper and easier to deploy, collaborative schemes are often far more effective.

"In this paper, we present an architecture for enabling collaborative coexistence of heterogeneous CR networks over TVWS, called Symbiotic Heterogeneous coexistence ARchitecturE (SHARE)," the researchers wrote in their paper, pre-published on arXiv.

As suggested by its name, the new approach devised by this team of researchers draws inspiration from inter-species relations observed in biological ecosystems. In biology, symbiotic relations entail the coexistence of different species that form relations via indirect coordination.

"By mimicking the symbiotic relationships between heterogeneous organisms in the stable ecosystem, SHARE establishes an indirect coordination mechanism between heterogeneous CR networks via a mediator system, which avoids the drawbacks of direct coordination," the researchers explain in their paper.

The SHARE architecture developed by the researchers allows two heterogeneous CR networks to coexist in TVWS, via a mediator-based indirect coordination mechanism. This mechanism avoids the drawbacks typically associated with direct coordination mechanisms. Inspired by models in theoretical ecology, the researchers devised two SHARE algorithms that allow each coexisting CR network to autonomously complete two key spectrum sharing tasks.

"SHARE includes two spectrum sharing algorithms whose designs were inspired by well-known models and theories from theoretical ecology, viz, the interspecific competition model and the ideal free distribution model," the researchers said.

The two SHARE algorithms developed in this study allow individual CR networks to dynamically determine their spectrum share, which is proportional to their bandwidth requirements, and select channels that improve the system fitness. In their analyses and simulations, the researchers found that their architecture guaranteed a stable equilibrium of coexisting networks, achieving a fair allocation of spectrum and maximizing the system fitness.

More information: Heterogeneous coexistence of cognitive radio networks in TV white space. arXiv:1902.06035 [cs.NI]. arxiv.org/abs/1902.06035