Spectrum Decision for Cognitive Radio Networks

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Cognitive Radio Networks (CRNs) are a key technology suggested to be part of 4G and beyond. The fundamental concept is to let Secondary Users (SUs) have temporal free access to spectrum bands not occupied by Primary Users (PUs). Since SUs are not allowed to cause harmful interference to PUs, SUs need to select the most available spectrum bands for access, also known as *spectrum decision* [1].

By performing spectrum sensing, SUs can learn the characteristics of parameters, e.g., received signal strength, interference, path loss. Based on this, the most available band is selected [1]. In Fig.1, we define the spectrum decision as a *black box* in terms of input characterizations, output selected band and internal function of decision making.

To deserve cognitive radios, SUs should learn from the statistical information about environment changes. In [2], the authors advance a statistical measure named *idle time*, which is used to characterize how long a PU absence is the channel. As a consequence, the most available band is attributed to the longest idle time expected in the near future. In [3], the authors apply Game Theory to CRNs, so that SUs are considered to behave in a socially constructive way when doing spectrum access. In [4], the authors suggest a biologically-inspired algorithm to achieve efficient spectrum sharing.

The above mentioned methods for spectrum decision lay the ground for researchers to approach CRNs. However, so far, these methods work independently from each other and different methods are used for different research goals. On the other hand, recent research focuses on setting up a practical CRN architecture [5]. This raises two important questsions.

- **Development**: do the researchers need to individually implement all suggested methods, or just suggest new methods?
- **Compatibility**: if the newly suggested methods are evaluated to be useful for spectrum decision, then how to easily make it practically applicable to other CRN architecture or testbeds?

Moreover, as the performance of spectrum decision depends on the observed characteristics of CRNs, we are facing two serious problems when designing a method for spectrum decision:

- **Reality**: the spectrum sensing needs to operate on a periodic time basis, while the PU activity may follow a continuous-time Markov process [6]. Therefore, the observation outcomes by spectrum sensing may be different from the reality.
- **Sharing**: when multiple SUs share the same statistics, a simple decision maker may lead to the same band. If a specific band is overcrowded due to this, then the Quality of Service (QoS) performance degrades.

To address these problems, we suggest a middleware called Spectrum Decision Support System (SDSS) abstractly illustrated in Fig.1(b). The goal of SDSS is to combine the different methods together and to make intelligent decisions based upon partial characterizations of CRNs.

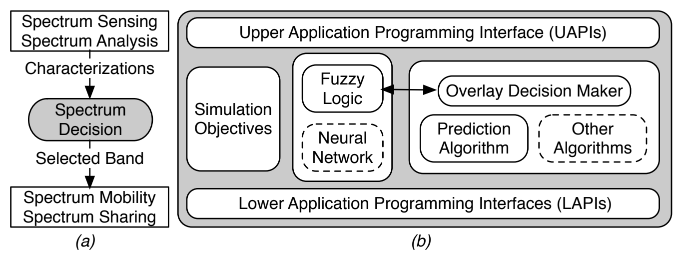

Fig. 1. Abstract SDSS.

In SDSS, by employing both *fuzzy logic* and *neural network*, the decision maker can combine different kinds of algorithms together. The UAPIs help users to embed SDSS into specific projects called *upper applications*, e.g., design of CRN architectures [5], setting up of CRN testbeds. The LAPIs help users to modify the old methods in SDSS and integrate new algorithms into SDSS. The new methods can be about research issues like spectrum mobility, spectrum sharing, spectrum decision. The updated methods in SDSS can be evaluated by experiments or simulations on the basis of the specific upper applications. Therefore, the functionalities of SDSS for spectrum decision can be improved and extended.

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