Military University of Technology

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Ph.D. Thesis Abstract

Cognitive radio networks' channel state prediction for dynamic spectrum management based on hidden Markov models

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The ever-increasing popularity of applications for wireless systems warrants for searching more effective spectrum resources management methods, which would ensure satisfactory transmission quality, service availability, and large capacity of radio interfaces. It is possible to achieve higher usage effectiveness of available frequency band through the use of a new spectrum usage philosophy – dynamic spectrum management.

Radio nodes in Cognitive Radio Networks identify unused portions of frequency spectrum. Radio nodes could operate in available frequency spectrum and not interfering with original users and/or not violating the earlier spectrum management policy, which in particular may contain a combination of licensed and unlicensed frequency bands. The existing solutions allow to determine the occupancy of channels only when it detects changes in the channel. It is an obsolete information for cognitive radio solution. We should acquire this kind of information in advance – practically, predict the future channel state.

Solution proposed in the dissertation require equipping the nodes with band sensing mechanisms and device necessary to decide which unoccupied frequency band will be used, and whether it needs to be vacated when the primary users begins its transmission. This is the basis for the cognitive radio concept. Uninterrupted coexistence of all spectrum users require usage of

complex decision-making rules, which would use frequency channel state information, estimated from radio environment parameters, channel modelling and channel state prediction.

In the dissertation proposed usage of the Hidden Markov Model (HMM) with prediction training algorithm for channel occupancy in a dynamic, changing environment of an ad-hoc network.

Markov models are a class of stochastic processes which can be used to model event sequence information. A system modeled using the Markov models is presented as a Markov process, the states of this process are invisible to the observer, but the output (observation) – a random function of the state – is visible. It was assumed that the channel can be observed as being one of the following state S1: idle and state S2: busy. This was the reason for the creation of two state Markov model, described at any time as being in one of a set of N distinct states, S1 and S2. At regularly spaced discrete times, the system undergoes a change of state (there is a possibility to go back to the same state) according to a set of probabilities associated with the state.

The program implemented in the dissertation predicts the subsequent state of the channel comparing the probability that the channel will be vacant in a given moment of time with the probability of the channel being occupied in a given moment of time. The predictor will indicate future occupancy or vacancy of the transmission (frequency) channel depending on higher probability value.

The following conclusion can be drawn from results analyses. First of all, the training of Hidden Markov Models using the learning algorithms described in the dissertation, allows the proper operations of the predictor. Moreover, a significant improvement between random and trained HMM parameters can be observed.

A reliable channel status prediction mechanisms should ensure a lower probability of wrong predictions of the channel status. The simulation results show how channel occupancy prediction that uses two training algorithms, may help to reduce the number of channel switches that a Secondary User may have to perform in a Cognitive Radio Network.