Research Proposal: Spectrum Sensing in Cognitive Internet of Things (C-IoT)

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Introduction:

The great problem under signal detection and signal processing in sensors, radar sensors, and communication systems such as cognitive radio networks is the additive and multiplicative noise. Improvement of the signal detection and signal processing performance and the high noise immunity of the wireless communication systems are the main goal of this research proposal.

The employment of the new signal detection and signal processing algorithms such as generalized approach to signal processing (GASP) [1] in sensor and communication systems shows significant improvements in performance comparing with the conventional algorithms. The GASP algorithm demonstrates superiority in detection performance under the same initial conditions in comparison with the other algorithms both for uncorrelated and spatially correlated antenna array elements. The GASP is based on a seemingly abstract idea: the introduction of an additional noise source, which does not carry any information about the signal for the purpose of improving the detection performance and noise immunity of complex signal processing systems in various areas of application.

The generalized detector (GD) [2]-[5] constructed based on GASP algorithm is a combination of the correlation detector and energy detector (ED). The GD decision statistics about the signal presence or absence is based on definition of the jointly sufficient statistics of the mean and variance of the likelihood function. Thus, an implementation of GD allows us to extract more information from the likelihood function and make a more accurate decision about the signal presence or absence in comparison, for example, with the matched filter (MF), correlation detector, and the ED. Theoretically, the GD can be applied to any signal processing system, for signals with known or unknown, deterministic or random parameters.

Spectrum sensing is needed to define the idle frequency bands (frequency holes), within the limits of which the entire operation of cognitive radio (CR) is relied on. The radio spectrum awareness and existence of primary users (PUs) are obtained by performing the spectrum sensing at the secondary users (SUs) or secondary access nodes. As a result, the CR systems allow the SUs to use the unutilized frequency bands (vacant utilization) without causing harmful interference to the PUs [6].

The internet of things (IoT) or internet of everything (IoE) main idea is to turn each physical object or device in the surrounding indoor or outdoor environment into a smart object with various processing and sensing capabilities [7].

Clearly, the cognitive IoT (C-IoT) describes the combination between CR abilities and IoT functions in order to supply the conventional IoT applications with the significant radio resources (according to the related connectivity and QoS standards) beside the other monitoring and adaption capabilities.

Research Objective:

Improving the signal detection and signal processing performance in adaptive communication, spectrum efficient communication, cooperative communication, and cognitive radio systems employing and developing new spectrum sensing techniques that fit the C-IoT requirements.

The proposed research plan is devoted to signal detection and signal processing in cognitive radio (CR) and IoT systems. The research vision can be summarized as:

- Improve the spectrum sensing performance in CR networks under the correlated antenna array elements when the noise variance is known, and also when the noise variance is unknown.
- The sample complexity and the SNR wall phenomenon alleviation under noise power uncertainty will be considered for several detectors (GD, ED, MF, etc).
- A Combination between the spectrum sensing algorithm and the compressed collaborative scheme for wideband spectrum sensing is proposed using the low density parity check (LDPC) measurements matrix. This idea promises a small number of required measurements with high probability of detection, low probability of false alarm and probability of miss (low probability of error) that leads to meet the IEEE 802.22 standard constraints.

- The effects of the secondary user (SU) interference on the spectrum sensing performance will be considered following a modified method that allows us to simply averaging the random interfering SU signals power in terms of moment generating functions (MGFs).
- The optimal detection threshold at the low SNR region over the additive white Gaussian noise (AWGN), Nakagami-m fading, Rician fading, Rayleigh fading channels, and other dispersive fading models will be derived based on the minimum probability of error criterion.
- Noise power estimation technique with minimum estimation error is required to reduce the noise uncertainty negative effects on the sensing performance and reduce the sample complexity. This point is a part of the research plan.
- Two stages scheme for coarse and fine spectrum sensing will be under investigation using the conventional well known detectors for the coarse stage and the GD model signal generator for the fine stage.
- Cooperative spectrum sensing when the SUs exchange the local sensing results with each other is an important part of the research considering that every SU is equipped with the GD.

The expected effects and results in the case of sensor systems and CR networks can be listed and addressed as follows:

- High probability of detection;
- Low probability of false alarm and probability of miss (low probability of error) that leads to meet the IEEE 802.22 standard constraints;
- Efficient sample complexity;
- SNR wall phenomenon alleviation under noise power uncertainty;
- Better noise and interference immunity.
- Employing and developing more accurate noise uncertainty models based on conditions close to practice.

References:

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