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Editorial

Cognitive radio based smart grid: The future of the traditional electrical grid

The traditional electrical grid is currently undergoing a range of modernization efforts and becoming a smarter grid [1]. In the traditional electrical grid, energy is distributed from the generation plants to the consumers via large nationwide transmission and distribution networks. Information monitoring and management in these traditional electrical networks is typically limited to the distribution networks that distribute electrical power within a city to the individual consumers. Due to rising demands, aging infrastructure, reliability concerns, and the emergence of renewable energy sources, the smart grid (SG) concept is being introduced [2].

Typically, there are three architectural building blocks of the smart grid. First, Home Area Networks (HANs), which connect the devices within the consumer premises, such as smart meters, distributed renewable energy sources, and Plug-in Electric Vehicles. Second Neighborhood Area Networks (NANs), which interconnect multiple HANs, and communicate the collected information to Wide Area Networks (WANs). Third, WANs, which serve as communication backbone.

The smart grid will be equipped with state-of-the-art information and communication technologies (ICT) and smart devices, such as smart meters, wireless sensor nodes, and load balancing through real time demand side management, pervasive computing, sensing devices, broadband communication, and intelligent management techniques [3-10]. Additionally, wireless sensor nodes along with actuator networks can be very useful to give access to remote sites and places where human intervention is not possible [11, 12]. Such information and novel communication technologies have the potential to significantly improve the efficiency, effectiveness, reliability, sustainability, and stability of the electrical grid.

The smart grid will adopt several communication technologies to fulfill the wide range of functionalities expected from the modern electricity grid. These communication technologies range from both wired and wireless communication technologies, such as Bluetooth, ZigBee, WiFi, and cellular networks, to power line communication and optical fiber communication links. However, the selection of any communication technology for the smart grid can be driven by multiple factors such as required data rate, cost, environmental condition, data type, and network architecture. That is why, it's important to deal with coexistence communication technologies focusing on adaptive systems able to consider quality of services (QoS), trust and security parameters [13, 14].

In order to meet the complex communication needs of the smart grid innovative approaches to communicate various data over a range of environments, spanning from individual homes and neighborhoods to wide area networks covering electrical interconnections is required. In this context, cognitive radio (CR) based smart grid systems emerge as a promising candidate [15]. Inclusion of cognitive radio based communications in the smart grid may help in overcoming radio spectrum shortages by flexibly using licensed and unlicensed frequency spectrum bands for future smart grid applications. Cognitive radio based smart grid systems may also reduce the power consumption and increase the interoperability among heterogeneous communication networks. Besides, CR technology can benefit from the underutilized white spaces and addresses signal dimension, license perspective, and transmission perspective of white space usage [16].

In this special issue, we included eight papers in the domain of Cognitive Radio based Smart Grid systems. More specifically, this special issue has focused on recent developments in Cognitive Radio based communication techniques with applications to the Smart Grid. These articles are gathered into the three following areas: (a) Reliability, trust, and security in CR-based SG, (b) Channel selection, spectrum sharing, and QoS in CR-based SG, and (c) CR-based smart home management in SG.

I. Reliability, trust, and security in CR based SG

When moving from the traditional electrical grid to the smart gird, Information and Communication Technologies

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(ICT) and smart devices will be used. These smart devices range from wireless sensor nodes to actuator nodes, which will be deployed in power generating stations, transmission lines, distribution centers, and control rooms. The main responsibility of these sensors is to monitor events and then based upon observed events; an actuator will perform prescribed actions. In case of failure of detection of an emergency event or failure to communicate it to the control room, there may be a malfunction in the smart grid operation. Thus, reliable detection and communication plays an important role in the successful operation of the smart grid.

Let us consider the context of smart meters, which are installed in millions of consumer premises. The collection of information from these smart meters and the reliable information transmission is essential to maintain the trust of end-users and to ensure accurate billing. However, if the information is compromised then the performance of the smart grid will surely degrade. Thus, trust aware, secure and privacy preserving protocols and schemes are required for the future smart grid. In this regard, we included three articles covering the aspects of trust, reliability, and security in the smart grid.

The article entitled “Opportunistic reliability for cognitive radio sensor actor networks in smart grid” by Ozgur Ergul, A. Ozan Bicen, and Ozgur B. Akan presents an analysis of reliability in wireless sensor actor networks. Ergul et al. propose a scheme in which the actor nodes cooperate with each other to reach a global consensus. Finally, Ergul et al. study the impact of interruptions due to primary user arrivals, wireless channel errors, and mis-detection of primary users.

The article entitled “Trust based reliable transmission strategies for smart home energy management in cognitive radio based smart grid” by Uthpala Subodhani Premarathne, Ibrahim Khalil, and Mohammed Atiquzzaman proposes a trust-based framework to improve delay sensitive data transmissions. The proposed trust-based framework is evaluated through spectrum sensing data falsification attack and showed enhanced reliability.

The article entitled “Resilient to shared spectrum noise scheme for protecting cognitive radio smart grid readings – BCH based steganographic approach” by Alsharif Abuadbba, Ibrahim Khalil, Ayman Ibaida, and Mohammed Atiquzzaman proposes a model that combines error detections and correction techniques with advanced steganographic algorithms in cognitive radio based smart meters.

II. Channel selection, spectrum sharing, and QoS in CR based SG

One of the reasons to use cognitive radio in smart grid is to facilitate the communication by using the spectrum efficiently. In fact, cognitive radio will perform spectrum sensing to identify the underutilized spectrum and then perform spectrum decision, a.k.a., channel selection, for communication purpose. Thus, channel selection is crucial for effective communication in the smart grid.

In the context of smart meters, spectrum sharing is also important. Without the use of cognitive radio, primary users may suffer from high interference. Moreover, Quality of Service (QoS) for communication infrastructure is also important. Thus, considering the importance of channel selection, spectrum sharing and QoS, we include three articles.

The article entitled “Flexible channel selection mechanism for cognitive radio based last mile smart grid communications” by Saud Althunibat, Qi Wang, and Fabrizio Granelli propose a channel selection scheme for cognitive radio based smart grid systems. Based upon the type of the transmitted data, the proposed channel selection scheme adapts. Through simulation results, Althunibat et al. demonstrate the efficiency of proposed scheme compared to the non-adaptable channel selection schemes.

The article entitled “Maximizing the link throughput between smart meters and aggregators as secondary users under power and outage constraints” by Pedro H.J. Nardelli, Mavricio de Castro Tomé, Hirley Alves, Carlos H.M. de Lima, and Matti Latva-aho studies a spectrum sharing technique in the presence of static and mobile elements for distribution grids. More precisely, Nardelli et al. assess the communication link from smart meters to aggregators over the primary uplink channel.

The article entitled “Communication time delay estimations for load frequency control in two-area power system” by Vijay P. Singh, Nand Kishor, and Paulson Samuel analyzes the Quality of Service for communication infrastructure. The considered communication infrastructure is a wide area monitoring system having load frequency control of two-area power system.

III. Smart home management in CR based SG

There are several applications of cognitive radio in the context of the smart grid. One important application is smart home management and residential load management. This application will not only help to reduce the power consumption at the consumer’s end, but also help to optimize the scheduling and usage of electrical equipment for customer satisfaction. To deal with these aspects, we include two articles.

The article entitled “Application of hierarchical and distributed cognitive architecture management for the smart grid” by Jacques Palicot, Christophe Moy, Benoit Résimont, and Rémi Bonnefoi proposes a hierarchical and distributed cognitive architecture management for the smart grid. To illustrate the efficiency and benefits of proposed architecture, Palicot et al. used it for smart home management. The proposed architecture was shown to help reduce the power consumption in the smart home context.

The article entitled “Iterative learning for optimal residential load scheduling in smart grid” by Bo Chai, Zaiyue Yang, Kunlun Gao, and Ting Zhao proposes a residential load scheduling scheme. Through convex optimization, Chai et al. optimize the power consumption expenses, customer satisfaction, and robustness of schedule subject to uncertain electricity price, in the context of residential load.

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