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Editorial

Smart Grid: ICT Control for Distributed Energy Resources

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1. Introduction

The fact that the electrical grid represents a critical and complex infrastructure has prevented it from experiencing major breakthroughs during decades. Therefore, some problems and inefficiencies have been carried around for a long while, up to the point that traditional electrical grid is far away from being prepared to face incoming challenges, such as properly integrating the foreseen high penetration of Distributed Energy Resources (DER), mainly intermittent and stochastic renewable generation, electric vehicles and energy storage, or proactively controlling the energy demand by means of the so-called Demand Response (DR) programs.

As a result, the electrical grid is currently undergoing slowly but surely its inexorable metamorphosis under the new paradigm of the so-called Smart Grid. This metamorphosis basically entails evolving from a highly centralized and static system, where few energy generators supply electricity to a huge number of consumption points without exchanging information in real time, into a highly distributed and dynamic system, with many low capacity, geographically distributed generators, which are able to communicate with the consumption points in order to coordinate and optimize their operation.

Ensuring the balance and stability of the electrical grid under this new paradigm requires the deployment of a vast number of sensors and actuators which will generate an unprecedented huge amount of data. Thus, high-performance, reliable, secure, and scalable communications networks and Information Technologies (IT) systems play a central role in the Smart Grid, which is driving the next wave of research and innovation in the Information and Communications Technology (ICT) sector.

The aim of this special issue was to gather high-quality cutting-edge research papers addressing the use of distributed sensor and actuator networks in Smart Grids, including topics such as novel ICT architectures, wireless and wired communications technologies, interoperability and conformance testing, big data and analytics, and cloud computing, and applications such as Advanced Metering Infrastructures (AMIS), Demand Response (DR), Wide Area Monitoring Systems (WAMS), or transportation electrification.

The special issue has attracted the submission of 17 papers. After a thorough peer-review process, seven papers have been accepted for publication. The topics covered in these papers range from Advanced Metering Infrastructures and Demand Response to substation automation and smart lighting, including wireless and powerline communications networks and cybersecurity.

2. Related Works

Specifically, in the paper entitled "Analysis of Secure TCP/IP Profile in 61850 Based Substation Automation System for Smart Grids," O. Khaled et al. bring together such trendy topics within the Smart Grid as IEC 61850 and cybersecurity. The paper focuses on analyzing the proposed secure TCP/IP profile for Manufacturing Message Specification (MMS),

testing different cipher suite combinations, and examining whether by applying TLS the strict performance requirements of IEC 61850 can be achieved or not. As a result of the study, the authors recommend a list of cipher suite combinations under IEC 61850.

In the paper entitled "λ-Augmented Tree for Robust Data Collection in Advanced Metering Infrastructure," J. Kamto et al. address the robustness of data collection in wireless mesh neighborhood area networks for advanced metering infrastructure (AMI). In order to mitigate the weakness of tree topology of smart meters (SM), the authors design a highly connected tree with a set of backup links. A topology repair scheme is also proposed to address the impact of a SM node failure on the connectivity of the augmented tree network. Such a topology repair scheme specifically targets highly critical SM (the so-called cut SM) by selecting backup parent SM to cover its children. Detailed algorithms and related theoretical and complexity analysis are provided along with simulation results pointing out that sufficient redundancy is provided to alleviate data loss at the cost of signaling overhead.

In the paper entitled "Planning and Performance Challenges in Power Line Communications Networks for Smart Grids," M. Seijo et al. provide an overview of Power Line Communications (PLC) technologies, paying special attention to Powerline Intelligent Metering Evolution (PRIME) and Broadband over Medium Voltage Power Lines (MV-BPL). The authors identify some of the most relevant challenges that PLC networks face nowadays when being used to monitor and control the power distribution networks of the Smart Grids, presenting also a set of cutting-edge software tools that aim to provide solutions to such challenges. Such tools include a traffic analysis and diagnosis tool and a network simulation tool for PRIME technology and a cell simulation tool for MV-BPL technology.

In the paper entitled "Automated Residential Demand Response Based on Advanced Metering Infrastructure Network," J. Seo et al. address such an interesting topic as taking advantage of advanced metering infrastructure in residential demand response. The international standard protocol OpenADR 2.0 is used to realize a fully automated DR (ADR). Smart meters are modified to support this protocol while maintaining current structure and function. Simulation and demonstration tests are conducted in order to confirm conformance of the protocol and to verify load variations of home appliances under the proposed ADR model.

In the paper entitled "Errors Nature of the Narrowband PLC Transmission in Smart Lighting LV Network," P. Kiedrowski provides a characterization of Frame Error Rate (FER) versus Signal to Noise Ratio (SNR) in Smart Lighting Low Voltage (LV) networks based on gas-discharge lamps and Light Emitting Diodes (LED) individually controlled via Narrowband Power Line Communications. The work is based on measurements collected from field trials over a period of one year. A different influence of the frame length on the FER versus SNR was observed for the gas-discharge and LED LV networks, which led to examining the bit error distributions. As a result, the study concludes that bit error distribution characteristics of gas-discharge lamps present extra oscillation compared to LED. These results can be useful to future deployments of Smart Lighting systems based on Narrowband PLC networks.

In the paper entitled "Pilot-Less Time Synchronization for OFDM Systems: Application to Power Line Receivers," A. S. Lalos et al. address the communications issues related to time and sampling frequency offsets in Orthogonal Frequency-Division Multiplexing (OFDM) modulation schemes for Broadband Power Line Communications. In particular, the authors propose a novel OFDM receiver architecture that mitigates jointly time and frequency errors while being compatible with Broadband PLC technologies. Simulation results show, under realistic channel and noise conditions, that the proposed receiver provides enhanced robustness to synchronization imperfections as compared to conventional approaches.

In the paper entitled "Optimizing Data Access for Wind Farm Control over Hierarchical Communication Networks," J. Madsen et al. provide an evaluation of the impact of communication network delay to estimate the fatigue of a wind turbine based on a sensor placed on it. The automatic controller in charge of estimating the fatigue was shown to be very sensitive to communication delays and packet losses. For this reason, a number of wired and wireless technologies were tested to assess their behavior. As a conclusion, 3G wireless technology is pointed as the best alternative to optimize the controller's performance.

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