Big Data Research ••• (••••) •••–•••

Contents lists available at ScienceDirect

Big Data Research

www.elsevier.com/locate/bdr

Big Data Analytics for Dynamic Energy Management in Smart Grids ☆

Panagiotis D. Diamantoulakis [b,*], Vasileios M. Kapinas [b], George K. Karagiannidis [a,b]

[a] *Department of Electrical and Computer Engineering, Khalifa University, PO Box 127788, Abu Dhabi, United Arab Emirates*
[b] *Department of Electrical and Computer Engineering, Aristotle University of Thessaloniki, GR-54124 Thessaloniki, Greece*

ARTICLE INFO

Article history:
Received 21 December 2014
Received in revised form 27 February 2015
Accepted 13 March 2015
Available online xxxx

Keywords:
Big data
Smart grids
Dynamic energy management
Predictive analytics
Artificial intelligence
High performance computing

ABSTRACT

The smart electricity grid enables a two-way flow of power and data between suppliers and consumers in order to facilitate the power flow optimization in terms of economic efficiency, reliability and sustainability. This infrastructure permits the consumers and the micro-energy producers to take a more active role in the electricity market and the dynamic energy management (DEM). The most important challenge in a smart grid (SG) is how to take advantage of the users' participation in order to reduce the cost of power. However, effective DEM depends critically on load and renewable production forecasting. This calls for intelligent methods and solutions for the real-time exploitation of large volumes of data generated by the vast amount of smart meters. Hence, robust data analytics, high performance computing, efficient data network management, and cloud computing techniques are critical towards the optimized operation of SGs. This research aims to highlight the big data issues and challenges faced by the DEM employed in SG networks. It also provides a brief description of the most commonly used data processing methods in the literature, and proposes a promising direction for future research in the field.

1. Introduction

A smart grid (SG) is the next-generation power system able to manage electricity demand in a sustainable, reliable and economic manner, by employing advanced digital information and communication technologies. This new platform aims to achieve steady availability of power, energy sustainability, environmental protection, prevention of large-scale failures, as well as optimized operational expenses (OPEX) of power production and distribution, and reduced future capital expenses (CAPEX) for thermal generators and transmission networks [1]. The upcoming technology in the framework of SG facilitates the development and efficient interactive utilization of millions of alternative distributed energy resources (DER) and electric vehicles [1–3]. To this end, each consumer location has to be equipped with a smart meter for monitoring and measuring the bi-directional flow of power and data, while supervisory control and data acquisition (SCADA) systems are needed to control the grid operation.

While dynamic energy management (DEM) in conventional electricity grids is a well-investigated topic, this is not the case for SGs. This is due to its much more complicated nature, since complex decision-making processes are required by the control centers [4,5]. Energy management systems (EMSs) in SGs include i) real-time wide-area situational awareness (WASA) of grid status through advanced metering and monitoring systems, ii) consumers' participation through home EMSs (HEMS), demand response (DR) algorithms, and vehicle-to-grid (V2G) technology, and iii) supervisory control through computer-based systems [6]. A typical overview of the SG and the included systems and technologies is given in Fig. 1. The quality and reliability of the data collected is a key factor for the optimized operation of the SG, thus rendering data mining and predictive analytics tools essential for the effective management and utilization of the available sensor data [7]. This is because effective DEM relies dramatically on short-term power supply and consumption forecasting, which handles prediction horizons from one hour up to one week [8]. Additionally, the sensor data contains important correlations, trends, and patterns that need to be exploited for the optimization of the energy consumption and the DR, among others [4]. Most of the research related to data mining in SGs deal with predictive analytics and load classification (LC), which are necessary for the load forecasting, bad data correction, determination of the optimal energy resources scheduling, and setting of the power prices [9,10]. The efficient processing of the produced vast amount of data requires increased data storage and computing resources, which imply the need for high performance computing (HPC) techniques.

☆ This article belongs to BDA-HPC.

* Corresponding author.
E-mail addresses: padiaman@auth.gr (P.D. Diamantoulakis), kapinas@auth.gr (V.M. Kapinas), geokarag@auth.gr (G.K. Karagiannidis).

http://dx.doi.org/10.1016/j.bdr.2015.03.003
2214-5796/

Please cite this article in press as: P.D. Diamantoulakis et al., Big Data Analytics for Dynamic Energy Management in Smart Grids, Big Data Research (2015), http://dx.doi.org/10.1016/j.bdr.2015.03.003