ARTICLE IN PRESS

Utilities Policy xxx (2016) 1–12

Contents lists available at ScienceDirect

Utilities Policy

journal homepage: www.elsevier.com/locate/jup

A hybrid approach to building a multi-dimensional business intelligence system for electricity grid operators

Jelena Lukić [a], Miloš Radenković [a], Marijana Despotović-Zrakić [b], Aleksandra Labus [b], Zorica Bogdanović [b, *]

[a] Public Enterprise Elektromreža Srbije, Belgrade, Serbia
[b] Faculty of Organizational Sciences, University of Belgrade, Serbia

A R T I C L E I N F O

Article history:
Received 11 December 2014
Received in revised form
21 June 2016
Accepted 21 June 2016
Available online xxx

Keywords:
Business intelligence
Data-warehouse
Data-warehouse design
Smart grids

A B S T R A C T

This paper proposes a new methodology for building multi-dimensional data-warehousing and business intelligence systems for utility companies. The proposed approach can be used by any utility company that wishes to take advantage of the principles and recommendations gained through a critical analysis of the Kimball and ASAP methodologies. The results show that this new approach can be incorporated as a cornerstone for business intelligence systems operating in a data-rich environment. It can be successfully designed and used for various reporting purposes of various business segments of an organization. The approach was tested by applying it to electricity market analysis of the Serbian energy transmission system and market operator “Elektromreža Srbije” in the context of smart-grid technologies.

1. Introduction

The electricity industry is beginning to use business intelligence (BI) technology to facilitate management analysis and decision-making. Success in the modern-day dynamic electric power business requires electricity market operators to have increased access to operational data and the ability to transform that data into actionable intelligence (Pfenninger et al., 2014). Further, the introduction of smart-grid technologies (Gungor et al., 2011), such as advanced metering and sensor infrastructures (Martać et al., 2016), has led to subsequent changes in companies' information systems and increased the need for real-time analytics. Business intelligence and knowledge management infrastructure are already recognized as a necessity for large energy systems that are adopting smart-grid technologies (Arends and Hendriks, 2014).

Electricity transmission companies normally measure their performance by using various types of qualitative and quantitative assessments (Abdalla et al., 2009; and Liu et al., 2006). Therefore, smart-grid technologies have resulted in an increasingly challenging process of getting relevant information by constantly measuring processes through key performance indicators (KPIs) and scorecards. KPIs represent an integral part of a BI solution and are a key contributor to the successful execution of a BI system and the overall enterprise strategy. BI allows companies to use the information at their disposal for supporting their processes and decisions by combining the organizational and technical aspects of information (Farrokhi and Pokorádi, 2012). Modern utility organizations have much to gain from the implementation of a BI system. Their highly complex organizational hierarchies coupled with inherent process complexity provide an ideal BI environment that could offer the utility operational flexibility as well as facilitate various reporting and analytical requirements. In order to efficiently manage the implementation of a BI solution in this highly complex environment, a methodology should be carefully chosen.

By examining and comparing frequently used methodologies for designing business intelligence systems, this research aims to identify and evaluate the phases of each methodology in order to provide guidelines and recommendations for a mixed approach. The proposed methodology is well suited for the development of a robust business intelligence system that can successfully tackle the process complexities of utility companies. A large part of the article is devoted to objectives and tasks that are realized while building and implementing business intelligence systems. In the proposed methodology, the extended star schema is used to achieve clear abstract modeling, while allowing greater flexibility when it comes to master data.

* Corresponding author.
E-mail address: zorica@elab.rs (Z. Bogdanović).

http://dx.doi.org/10.1016/j.jup.2016.06.010
0957-1787/

One of the basic goals of this research is to integrate and extend the findings of previous research by developing, testing and refining the traditional approach to BI for specific purposes, applications, and technologies. In order to achieve the goal of building a comprehensive data-warehouse solution, a well-defined "bottom-up" implementation methodology, similar to that advocated by Ralph Kimball et al. (2008) was adapted and combined with ASAP's high-quality control standards, requirements, and analysis. This allows for the best of both worlds: the complexity and detail of the Kimball Lifecycle and its focus on development of new objects, and the advantages of ASAP's close ties to existing ERP systems. For the purposes of evaluating the proposed hybrid methodology, this paper provides a brief overview of current issues related to the data-warehouse and business intelligence solutions for electricity markets (EM). The proposed methodology is evaluated for Public Enterprise "Elektromreža Srbije" (PE EMS), the Serbian transmission system and market operator. The practical evaluation shows how the methodology can help those who are familiar with the Kimball methodology, and work within the constraints of the ASAP methodology, to modify their existing BI approach in order to deal with customer requirements not met by standard business content.

2. Related work

A contemporary need exists for establishing a strong relationship between BI and utility companies. Understanding business conditions at a more granular level ensures utilities increase their efficiency by turning the data at their disposal into actionable intelligence.

Business intelligence, as an important cornerstone for the process of decision-making, is necessary for successful operations and management of any organization, and its main capabilities include: information extraction, warehousing, and analysis of data. Recent research in the field of business intelligence indicates that valuable information can be extracted from non-structured data, allowing more accurate decision-making on all management levels. The ability of an organization to create a ubiquitous environment for all its data extractors and decision points is critical for success. By analyzing historical trends and emerging patterns across the organization, management has a greater chance of making more accurate predictions about possible decision outcomes.

A data-warehouse is considered among the most powerful decision support and business intelligence technologies that have emerged in the last decade (Alhyasat and Al-Dalahmeh, 2013). It is common knowledge that information is the chief asset used to assure competitiveness of the organization in the business world. The primary problem encountered by many organizations that heavily rely on information is the amount of the gathered data and the difficulty of accessing it. The main cause is the fact that there are many data formats, source systems, and data structures that are significantly different from one another. The problem is often manifested in the need to write and maintain hundreds of programs for extracting, transforming, and loading of the data in order to consolidate many different applications into a single database suitable for reporting and analysis. It is often the case that decision-makers cannot act solely on the information provided and must further mine and analyze the data in order to get required information. This whole process can be costly, inefficient, and very time consuming, and the logical choice is to adopt data-warehousing technologies. The volume of data in data-warehousing can be very high, particularly when considering the requirements for historical data analysis (Ballard et al., 1998).

A common belief among most project managers is that data-warehouse projects are difficult to manage. Data-warehousing project management differs significantly from other software projects in the sense that the data-warehousing projects can never really be completed. Every phase of the data-warehousing project has a start date and an end date, but the data-warehouse will never be considered to be in an end state, since the warehouse must constantly evolve with the enterprise in order to be useful. Roles and responsibilities conducted in traditional ways might not be suitable for such projects and waterfall methodologies have proven to be inadequate in running such projects. Testimony to this fact are the numerous failed data-warehousing projects, due to their dynamic nature; this is what makes such projects unique and suitable for agile methods (Kannan, 2011).

Sen and Sinha (2005) analyzed 15 different data-warehousing methodologies, which are fairly representative of the range of available approaches. Many commercial solutions for software components of data-warehouse environments address the definition and specification of dimensions, fact variables, and hierarchies. The study points to the fact that the ASAP methodology uses the extended star schema in contrast to most other DW methodologies, which offers far more in the form of master data management.

Analyzing the literature, we highlight the following:

- Business intelligence (BI) systems have been deemed as the high priority systems by various business leaders in the industry (Farrokhi and Pokorádi, 2012). According to Ranjan, BI is a methodological transformation of data from any source system into information suited for result-oriented decision-making (Ranjan, 2009). Ranjan also researches the concepts and components of a BI system, implementation benefits, factors influencing the choice of the system, technological requirements, design and implementation, and various BI techniques. BI's primary goal is to offer support that, through a closed loop, links strategies, design, and execution with business intelligence (Seufert and Schiefer, 2005).
- Performance management is advanced when business goals are translated into KPIs, and used to measure business processes in relation to the defined goal values. Current BI approaches are subordinated to business management systems. Most BI systems are developed as systems for measuring success and are not used for decision-making purposes. KPIs are widely used in many companies (Masayna et al., 2007). Improvements to the quality and clarity of these indicators have widespread industry and societal benefit, including in the electricity sector (EPRI, 2003). Existing reporting systems based on performance indicators, which emphasize electricity data monitoring, lack the ability to create data aggregation or support data analysis for delivering reports and identifying actionable information (Li et al., 2013).
- Data-warehousing (DW) is considered to be one of the most powerful technologies for decision support and business intelligence (Alhyasat and Al-Dalahmeh, 2013). DW technologies were developed in order to integrate heterogeneous data sources for analytical purposes (Oueslati and Akaichi, 2010). Data-warehousing methodologies share a common set of tasks that include: business process analysis, data model design, architecture design, solution development and implementation (Inmon, 2002; Sen and Sinha, 2005; and Kimball et al., 1998).
- Multidimensional modeling (MM) requires specialized techniques for data design that loosely relates to the traditional ways of data modeling (Jindal and Taneja, 2012). The most common representations of dimensional model are the star schema and the extended star schema (Phipps and Davis, 2002).

Please cite this article in press as: Lukić, J., et al., A hybrid approach to building a multi-dimensional business intelligence system for electricity grid operators, Utilities Policy (2016), http://dx.doi.org/10.1016/j.jup.2016.06.010