A ubiquitous Web-based dispatcher information system for effective monitoring and analysis of the electricity transmission grid

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ABSTRACT

Effective electricity grid management and planning necessitates widespread installation of convenient data acquisition modules to obtain the relevant grid data in a timely manner. In this paper, we describe a ubiquitous Web-based dispatcher information system deployed on the Turkish electricity transmission grid. This large-scale system is utilized by the transmission system operator to effectively monitor the transmission grid and to analyze and summarize the gathered data automatically, in order to take proper short-term and long-term operational decisions. The system has the additional facilities to produce load forecasts and track long-term investment plans on the electricity grid. The architecture of the implemented system is described in details together with the demonstration of sample significant analysis and forecast results obtained from the system.

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1. Introduction

Electricity transmission grid operation is an important task with severe national implications, in addition to international implications if the grid under consideration is interconnected to externals grids. Generally, in every country, an organization termed the transmission system operator for electricity (commonly abbreviated as TSO or TSO-E) is the responsible body for the daily management of the grid in addition to planning and installation of the necessary grid equipment. These TSO tasks require timely and continuous data flow from the grid components to the TSOs. In order to fulfill this requirement, software systems with different characteristics are being built and installed on the electricity transmission grids. These software systems include wide area monitoring and control systems [1], supervisory control and data acquisition (SCADA) systems [2], power quality monitoring systems [3,4], wind power monitoring and forecast systems [5], load forecast systems [6], energy management systems [7], sequence of events recorders, special protection systems, and dispatcher information systems. These systems help TSOs effectively analyze the grid and take the appropriate operational measures both during the times of seamless operation and during the times of interruptions or failures. The installation of these systems is also important for the implementation of the much anticipated smart grids [8].

In this paper, we describe a ubiquitous Web-based dispatcher information system which has been installed on Turkish electricity transmission grid.[1] This system is henceforth referred to as YTBS (which is the abbreviation of the Turkish full name *Yük Tevzi Bilgi Sistemi* meaning '*Dispatcher Information System*') or as *system*. The main characteristics of YTBS are listed below:

- YTBS continuously acquires data from the grid components in about 1100 power plants and 1100 transmission substations in the country, by manual data entrance through its corresponding interfaces. These numbers correspond to about 99% of all the plants and substations connected to the grid, hence the system has a considerably high coverage.
- The grid component types monitored by the system include busbars, shunts, reactors, feeders, couplings, electricity transmission lines, transformers, and plant units. In addition to the dynamically-acquired hourly electrical data regarding these components, qualitative equipment information is also kept up-to-date by the system users.
- There are a total of about 2900 users of the system where these users are classified as belonging to one of the classes of *administrators*, *operators*, *plant users*, *substation users*, and *observers*. Each of these user classes has different privileges.

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[1] A preliminary and shorter version of this paper has been previously presented in [9].

- As YTBS is a Web-based system, adding new features and updates are made on the Web server which facilitates the system updates, and further promotes its widespread employment.
- The dynamic data acquired and stored through the system is utilized by several analysis applications which are integrated into the system whenever possible. Furthermore, the system provides the data to several other energy organizations through its relevant Web services.
- The system is currently being integrated with the related systems in order to replace the manual data acquisition through the related system interfaces. For instance, the system is integrated with the power quality monitoring system already installed on the transmission grid [3] so that the data is automatically inserted into the YTBS database from the grid components monitored by the power quality analyzers.

The rest of the paper is organized as follows: In Section 2, the architecture of the Web-based dispatcher information system is described in details. In Section 3, sample results obtained through the monitoring facilities of the system are presented. Sample analysis results from the system are provided in Section 4 together with the discussions of these results. Section 5 is devoted to the future research prospects based on the current system and finally Section 6 concludes the paper with a summary of its main points.

2. The architecture of the system

YTBS is a ubiquitous Web-based dispatcher information system built for and currently managed by TEİAŞ [10] which is the TSO of Turkey's electricity grid. The architecture of YTBS is depicted in Fig. 1 together with its interaction with the users and other organizations and systems.

The system has the necessary interfaces to acquire hourly data and other up-to-date information from the power plants, transmission substations, and national load dispatch center and the regional centers. The acquired data and the other information regarding the grid components are stored in the central database of the system located at the system center. Other data sources include the market servers and the existing power quality monitoring system from which the data is acquired automatically through the relevant Web services and again stored in the system database. This stored data and information is then made available to a number of energy organizations via the relevant Web services, and more importantly, to the TSO officials in the forms of tables, charts, single-line diagrams, and reports through via the corresponding system interfaces, and again to the TSO in the form of SMSs or mobile applications via a mobile operator facility. Based on user preferences, the data can also be automatically analyzed by third-party analysis applications and the results can be examined in relevant formats, and furthermore, short-term load forecasts produced by the system can be examined at different granularity levels such as at the country level and region level.

YTBS is implemented as a Java-based Web application using the JavaServer Faces (JSF) technology [11] and PrimeFaces [12] as the JSF library.

After this brief information about the system, in the following subsections; the data acquisition modules, the central system center, and the visualization/reporting facilities of the system are described in details.

2.1. Data acquisition modules

YTBS has proprietary pages to facilitate the acquisition of the required data from its users and other interacting systems as described below:
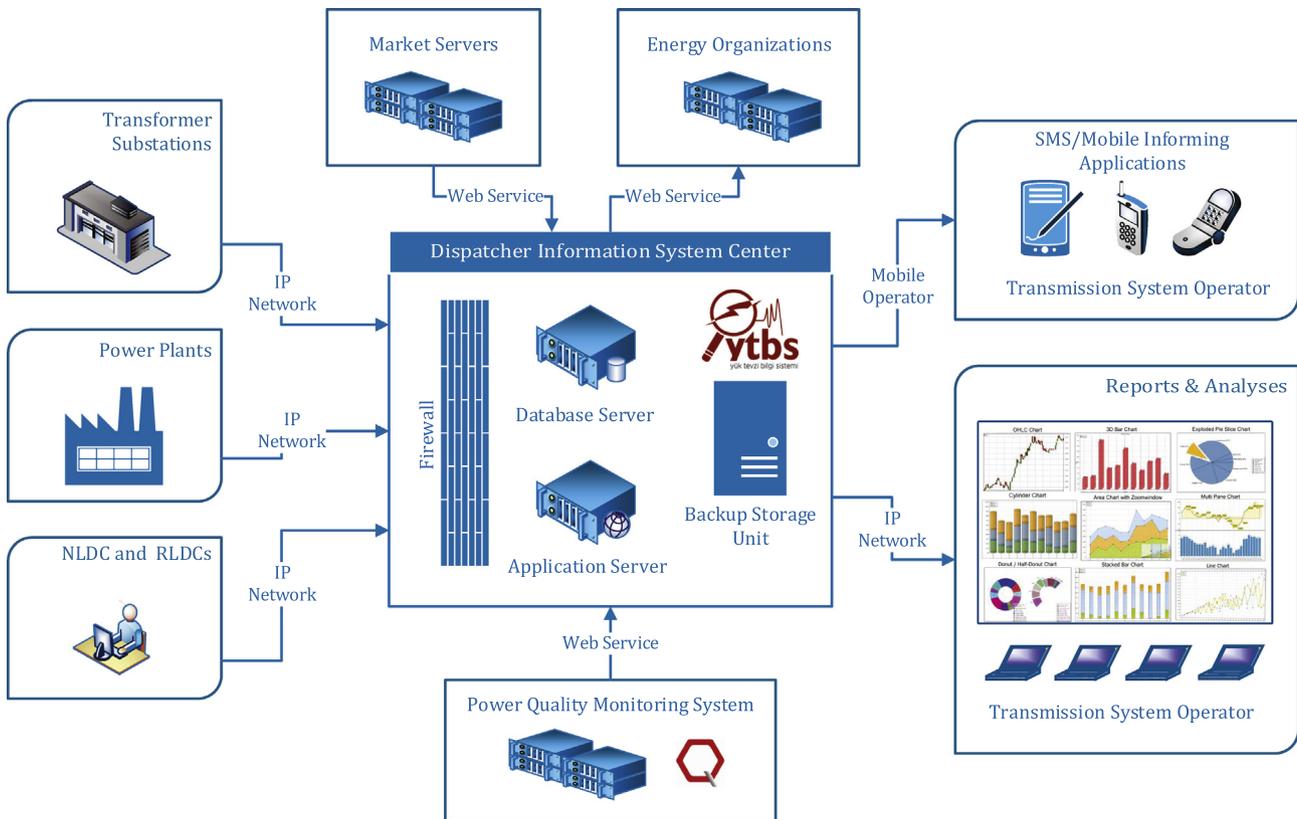

Fig. 1. The architecture of the Web-based dispatcher information system.