MONITORING OF POWER SYSTEM CONTROL FUNCTIONS A DATABASE APPROACH

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Key words: Power system, Control, Visualization, Monitoring.

ABSTRACT

Today, almost every country is going for the restructuring of the power system. The concept of restructuring of the power system assumes the availability of both the system operating point and historical information, almost at every minute. This implies that there is a need to create a centralized database for the power system which is subjected to the continuous up-gradation. Consequently, the recent and past information of power system is available to the electric utility for the purpose of network monitoring and its better planning. In this study a complete monitoring system based on a database approach is designed and implemented. The system uses the recent and past power system data in a monitoring process. The system has been simulated on a typical four-station power system which shows satisfactory results.

I. INTRODUCTION

Electrical energy providers constantly deal with demands to increase productivity and reduce costs. This translates into the need for administrators, engineers, operators, planners, field crews, and others to collect and act on the decision-making data. The power system vendors are following a trend to make devices smarter so they can create and communicate this data [1]. The various aspects of data repository are the data collection, data validation, updating, method of reporting and necessary backup, data storage and sharing the data among users through a network. It seems that the recent development of Information Technology (IT) may play a leading role to build what is called a power system information grid (PSIG). A typical PSIG is shown in figure 1 [2].

In this paper, the monitoring site of the PSIG has been analysed, and a monitoring approach based on data base technique is proposed, implemented and simulated.

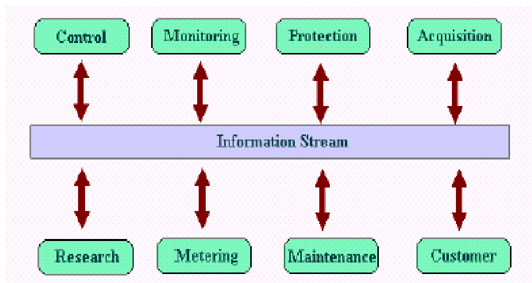

Figure 1. Power System Information Grid (PSIG)

Monitoring is the major tool for discovering information from the collected and generated data. It is an integrated process, and it is a result of a sequence of entities activation. These include:

1. Intelligent data recording

There are Intelligent Electronic Devices (IED) which records information about power system disturbances. They are capable of storing data in a digital format when triggered by conditions detected on the power system.

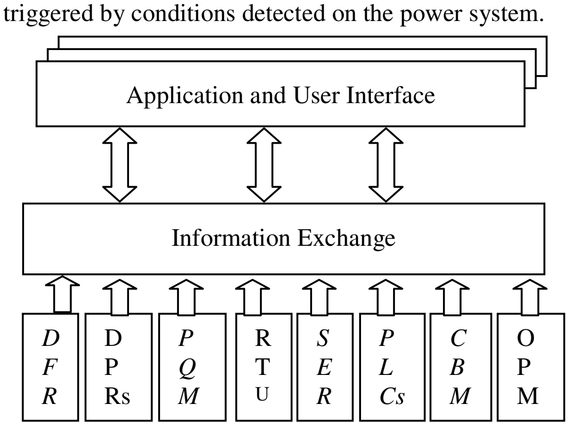

Figure 2. Data Integration and Information Exchange Concept

To better monitor power system equipment and disturbances, data coming from the following IEDs is considered (Figure 2): digital fault recorders (DFRs), digital protective relays (DPRs), power quality meters (PQMs), remote terminal units (RTUs), sequence of event recorders (SERs), programmable logic controllers (PLCs), circuit breaker monitors (CBMs), operator meters (OPMs) [6].

2. Data transfer mechanism

Data transfer program aims at reading the data from the real time data file, do necessary data processing and then store these data into a database. The real time data file system is organized in many blocks of data. Each block of data begins with an indicator 'start' and ends with an indicator 'end of data'. These blocks cover data for bus, power source, load, line, transformer, shunt capacitor, bus coupler, switchs, etc [2].

3. Data processing

The data processing is any software and/or hardware process that converts data into information. The processing is usually assumed to be automated and running on a mainframe, minicomputer, microcomputer, or personal computer.

4. Data basing

A database is a collection of persistent data in a special relational structure that is used by the application systems. A DBMS is used to set the base relations in the database.

5. Data visualization

The data visualization offers a mechanism for displaying large and complex data structures and their contents distributed among the processes of the target application, for instance distributed arrays [4].

In recent years some researchers gave their considerations to monitoring of power system control functions using on-line data processing. Grang and Liang in 2001 [6] have proposed a method for online monitoring of the voltage instability. Kezunovic and Latisko , in 2004 [5], have developed new functions for automated analysis of data collected in power system substations. Mladen and Tanja in 2005 [7], introduce a new paradigm for data integration where the substation field data recorded by monitoring and protection Intelligent Electronic Devices (IEDs) is used to supplement Remote Terminal Unit (RTU) data for Supervisory Control and Data Acquisition (SCADA) system. Our aim in this study is to propose a complete solution for using the power system history in real time monitoring task basing on a database approach. The following sections describe the design, coding, implementation and simulation results of the proposed system.

II. DESIGN AND IMPLEMENTATION OF THE MONITORING SYSTEM

The basic functional block diagram for a general visualization system is shown in figure 3:

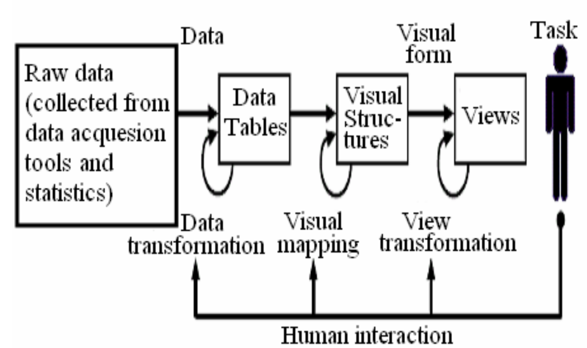

Figure 3. A visualization functional block diagram

The arrows back to the process from the user having a task to fulfil represent the interactive characteristics of visualization. The process can be controlled in every phase to achieve an appropriate result [8].

Figure 3 illustrates the phases of the proposed visualization process from raw data to the views shown to the user. The basic idea is that the original data is transformed or filtered in different ways until it is mapped as a graphical representation. The phases include:

Step 1. The raw data is first organized in relations or data tables, where the required relations between data units are defined and metadata is added. This is especially important for abstract data. Taking into consideration that data from natural sources often has explicit spatial relations.

Step 2. The relations are used as a basis of the generation of visual elements by transforming the data from numerical or textual representation to graphical objects. It is vitally important to choose such elements that can be processed effectively by human vision.

Step 3. Verify the data. There is a dedicated function called Verification which performs collecting, processing and data consistency checking. The status tracking function provides addition level in the process of data integration that enables verification of the data being collected and ensures the database consistency

Step 4. View transformations, adjusts the geometric representation and sets the parameters defining position, scaling, and clipping before the actual image rendering. Small circular arrows are used to emphasize that each phase can consists of actually multiple chained operations to the same category.

III. CONTROL FUNCTIONS & RELATED DATA

The data sources are the intelligent data record systems and data acquisition hardware which have been distributed among the system. There are thousands of data sets and information queering in the patch panel of the central computer in a power system. In any EMS system, these data have to re-organize before more processing. The basic proposed organization architecture in this study is a relation, which describes the attributes, entities and the interaction between the data set systems. An associative rule mining algorithm is used to classify the data set for any control function under test. Each control function has to have its own database relation. In our study the development of the system has been carried out with the application of the following relation schemas:

1. Optimal dispatch schema:

OPT{ID(number(3)), Date(date(10)), Hour(number(8)), Station(number(3)), PD(number(3))}.

Schema OPT is used to introduce the optimal dispatch representation on the visualization screen. The following standard optimal dispatch formulas are used in rule discovering:

$$P_i = \frac{\lambda - b_i}{2c_i} \quad (1)$$

Where,

$$\lambda = \frac{P_D + \sum_{i=1}^{N} \frac{b_i}{2c_i}}{\sum_{i=1}^{N} \frac{1}{2c_i}} \quad (2)$$

Where, b_i, c_i are cost coefficient random variables, of ith generator, P_D is received load, MW, P_i active power generation, a random variable and λ is Lagrange multiplier.

2. Cost coefficients- power demand schema:

By using the cost coefficients A, B and C as in table 1 and PD (power demand) as in schema 1,

Data	*Data type*
Unit	*Number*
P_{Min}	*Number*
$\boldsymbol{P_{max}}$	*Number*
A	*Number*
B	*Number*
C	*Number*

Table 1

The power reserve attribute

Power reserve (on line)=Pmax (on) – Pg

Power reserve(off line)=Pmax (on + off) – Pg

The proposed system is implemented using SQL Server DBMS and the application is designed and implemented using VB6.

IV. SIMULATION RESULTS

The proposed monitoring system which has been designed and coded is tested on a typical power system with four stations [9].The one- line diagram of the system is show in figure 4.

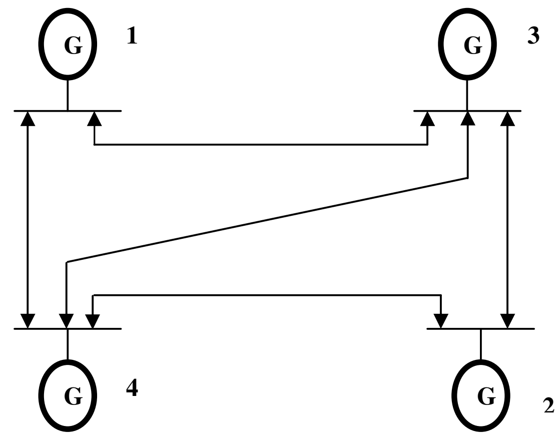

Figure 4. One line diagram of the tested system

The Visual Basic (VB) codes of the four stations represented in figure 4 is shown in table 2.

Data	*Data type*
ID	*Auto Number*
MaxStation1	*Number*
MaxStation2	*Number*
MaxStation3	*Number*
MaxStation4	*Number*

Table 2

The system consists of four stations; the base rating data is shown in Table 3.

units	P_{min} MW	P_{max} MW	a $/hr	b $/MWhr	c $/MW^2 hr
1	100	500	240	7	0.007
2	50	200	200	10	0.0095
3	80	350	220	8.5	0.009
4	50	150	200	11	0.009

Table 3. The rating data for the system

Cases studied

The proposed system has been tested for a typical off-line recorded data. To ensure the proper operation of the software, the functions are simulated separately, then the whole functions are combined in one package, to monitor these functions together and instantaneously depending on the on-line database which is created based on the power system response. The simulation of the package shows that whenever the data in the database updated the monitoring figures also updated instantaneously.
A one screenshot of the application after running on the data is shown in Figures (5-9).

The short term load forecasting in (MW) according to the data entered is shown in figure 5. Figure 6 illustrates the. Load reserve in (MW) that the reserve power available is used when a unit fails or an unexpected increase in load occurs. In this way the economic dispatching in (MW) can be obtained as given in figure 7. Figure 8 shows daily unit commitments for the four stations. It is assumed that the status of all stations is on. A screenshot of the application is illustrated in figure 9.

Results of the simulation study show that this method is appreciable and effective to monitor power system functions.

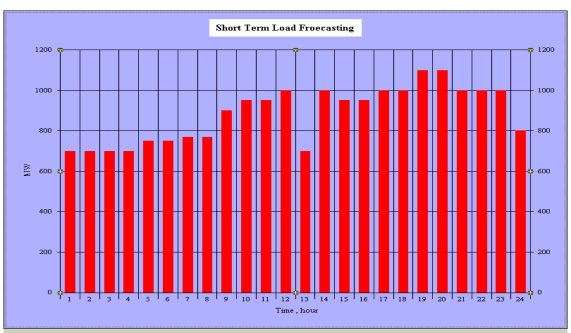

Figure 5. Short term load forecasting(MW)

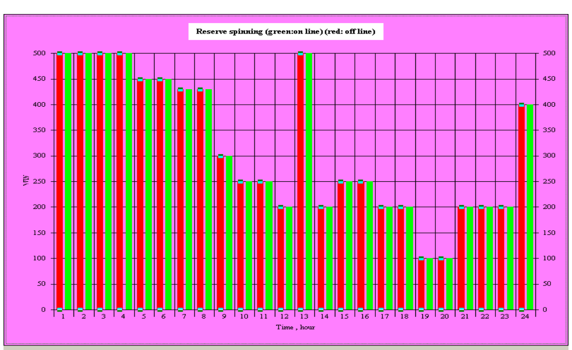

Figure 6. Load reserve (MW)

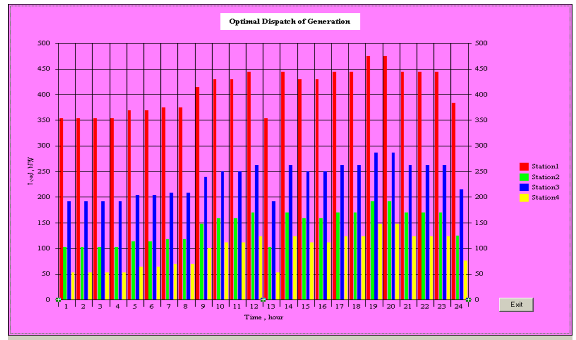

Figure 7. Economic dispatch(MW)

Figure 8. Daily unit commitments

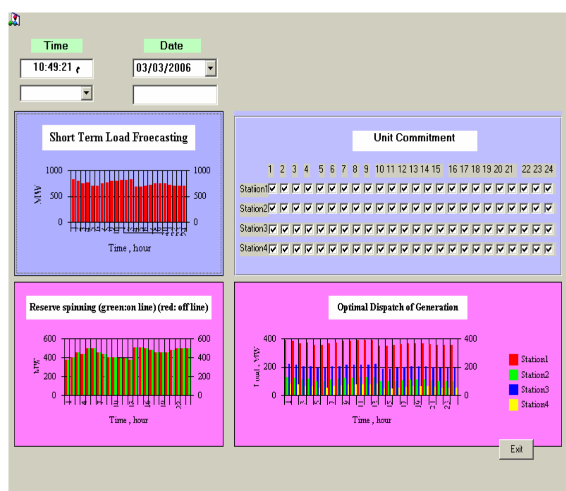

Figure 9. A screenshot of the application

V. CONCLUSIONS

In this study, a complete system for monitoring of Electrical Power System Control Functions has been proposed, designed, implemented and tested.

The proposed system is based on a database approach to develop the monitoring system using the recent and past information of the system.

Results show that by using a computerized data warehousing, a full automation of the relations between control functions can be achieved using the database approach.
From coding and algorithmic point of view, and because of the conventional data types of the power system control functions, VB in combination with SQL-Server are powerful tools in on-line system monitoring application. The real time test shows no delay in the application sense to any small changes in the data sets.

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