Real Time Decision Support for Energy Management

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Abstract—The complete energy information is required on finger tips for taking decisions at different levels of management like energy managers and Chief Executive Officers. This paper discusses the collection of complete real time data from different source systems such as SCADA, AMR, Databases and Internet which is pushed into an On Line Transaction Process (OLTP) and its immediate acquisition into On Line Analytical Process (OLAP). The real time data can be compared with forecasted data and with historical data for effective online energy management information reporting system. This real time data can be acquired every minute to analyse the end-to-end energy information for better decision making.

Index Terms: **AMM, Real –Time, OLTP, OLAP.**

I. INTRODUCTION

Electrical power is one of the most important infrastructure inputs, necessary for the rapid socio-economic development of a country. Increase in demand has led to the installation and incorporation of a large number of electrical power generation units with increased capacities in a common power grid, making the operation of the entire system sensitive to the prevailing conditions. Therefore, the extensive and complex power systems have become unmanageable using the conventional instrumentation and control schemes. Intelligent systems based on microprocessors and computers have been employed for online monitoring and control of modern large-scale power systems, in generation, transmission and distribution, thereby overcoming the complexities and drawbacks of the conventional instrumentation schemes.

An OLTP can integrate a large amount of data to be acquired from SCADA, AMM's, different databases and internet which is then processed through OLAP by comparing this Real time data with historical data and forecast data and the result of which is presented to the different Energy Managers and top level management.

The Complete end-to-end information such as Customer related data, power generation data, transmission data etc. can be extracted from different systems and pushed into a single system for online analysis [11].

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II. ARCHITECTURE OF REAL TIME DECISION SUPPORT FOR ENERGY MANAGEMENT INFORMATION SYSTEM

An Energy Management Information System (EMIS) is an important element of a comprehensive energy management program. It provides relevant information to key individuals and departments that enable them to improve energy performance. An EMIS can be characterized by its deliverables, features, elements and support. Deliverables include the early detection of poor performance, support for decision making and effective energy reporting. Features of an EMIS include the storage of data in a usable format, the calculation of effective targets for energy use and comparison of actual consumption with these targets. Elements include sensors, energy meters, hardware and software (these may already exist as process and business performance monitoring systems). Essential support includes management commitment, allocation of responsibility, procedures, training, resources and regular audits.

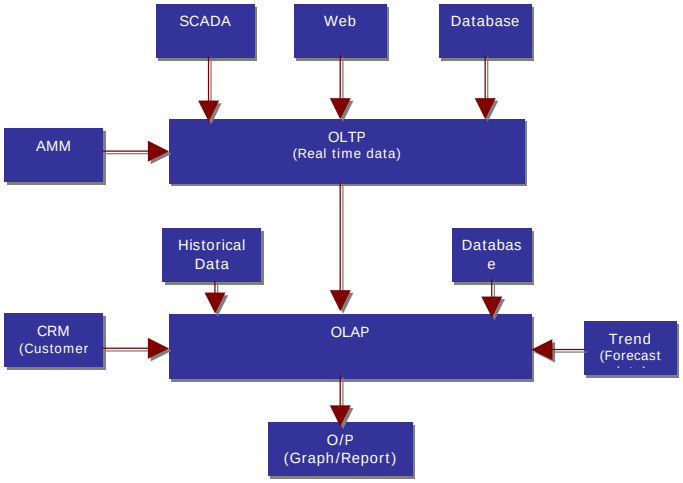

Fig 1 Block diagram of Real Time Energy Management Information System with OLTP and OLAP.

Architecture of above interfaces is discussed below

III. INTERFACES BETWEEN SCADA AND OLTP

Fast data access is the basic requirement of all real-time databases from SCADA to OLTP. In order to enhance operating efficiency of System analysis and decision software, a real-time system needs to provide a fast database access interface. Through this interface, database access efficiency can be the same as memory variable operation. One possible

realization is to map an entire partition of the database to the shared memory and return the result in a C structure through an Application Program Interface (API).

The real time database in SCADA extends traditional database to include in-memory database. Such RTDBMS are designed and integrated to Online Transaction Process. The Complete data is extracted to relevant application components of OLTP system.

Typically, data acquisition function collects real-time measurements of voltage, current, real power, reactive power, breaker status, transformer taps, etc. from substation RTUs every two seconds to get a snapshot of the power system in steady-state. The complete information is updated in OLAP system which helps real time data analysis.

The required data is loaded into the OLTP from SCADA by using the batch data conversion program.

IV. AMM TO OLTP

Controlling of real time link through Automatic Meter Management (AMM) will get complete energy consumption readings on different time buckets and these readings will be automatically updated into OLTP. Once the data is pushed into online transaction process, the subsequent transactions are done online. Due to this, we can operate and control the energy consumption at the customer level.

A. Automatic Meter Management (AMM)

AMM systems are used to record the meter readings remotely. This will improve the services offered to the clients by the company using the low-voltage power distribution lines as physical support for communications.

AMM provides multiple benefits to the customers who can avoid electricity invoices based on estimated consumption. The customers have a freedom to adjust their budgets.

Collaboration of AMM Systems and OLTP for Utilities will be managed and monitored through Composite Applications.

B. Automatic Meter Reading (AMR)

AMR in simple terms emphasizes the meter reading aspects of a particular utility function with the absence of any human intervention. The major benefits of AMRs are the automatic disconnections/reconnections without work order, automatic prepaid meter management, automatic handling of meter alerts to avoid frauds and automatic demand changes.

C. Interface between OLTP and AMMs

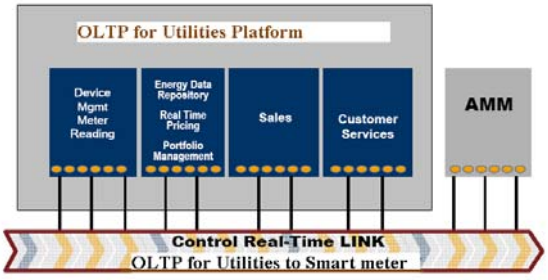

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Fig 2 Block diagram OLTP for Utilities

Electrical energy consumers are demanding better customer service, higher power quality, higher energy measurement accuracy and more timely data. Utility companies all over the world are being forced to find solutions giving greater information on the population's power consumption. Most of the utility companies are aiming to achieve the above goals using AMR.

At the Distribution Grid level, SCADA systems are usually linked with the primary substations, interfacing the high voltage with the medium voltage level. The installation of an AMR enables the data available from secondary substations.

The AMR system provides with numerous customer services and cost saving benefits which include:

- Saving the cooperative expenses in meter reading costs which include employee salaries and transportation costs.
- Improving billing accuracy, enhance customer service on billing and service issues and a substantial savings from misread or inaccurate readings.
- Allowing for better outage management and help provide usage data to commercial accounts in fifteen minute increments.
- Provide fully automated, daily meter readings on all meters.
- Offer improved electric service reliability.

D. Prepaid Metering System with AMR

In prepaid energy metering system, entire cumbersome process involved in conventional metering is removed. In this system, the consumer needs to buy energy cards which will be available at local vendors and can be inserted into the prepaid meter. After receiving a valid card, the meter will connect power supply to consumer load and update the present and balance readings. At the time of insertion it will give message display and warning signals if the card is inserted improperly. When card is taken out, every record of the meter is transferred into the energy card, such as

- Meter number at which it was used
- Time and date of insertion of card
- Previous "Current reading and Balance reading"
- Day wise consumption of energy

As this data is in electronic form, a consumer database can be created and maintained very easily. So, it effectively removes the cumbersome metering and billing process.

V. ON LINE ANALYTICAL PROCESS (OLAP) IMPLEMENTATION:

Decision makers in modern, globally operating enterprises frequently realize that their survival depends on the effective use of information. Till today, the entire data is spread across various systems. Therefore, an attempt to retrive the complete information in a single system has been discussed. In general, real time data warehousing supports tactical decision-making.

Real – time data acquisition can be used in two primary scenarios via the service API and via a web service.

The OLTP is connected by using Service API or RFC connection to OLAP. Real time data is transferred into OLAP on request using the service API. Different source systems are connected with different interfaces such as API and then the data will be loaded into Infoproviders.

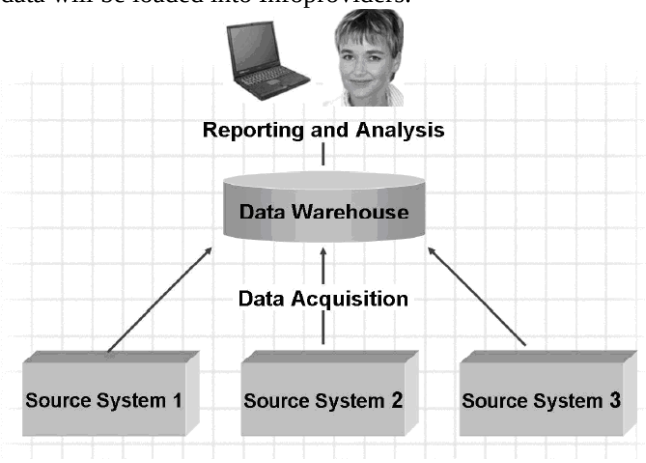

Fig 3 Heterogeneous Source System Environment

Real-time data is collected automatically at predetermined intervals. For a similar cost, measurements can be recorded every day or every second. This will improve overall energy management. The EMIS sole focus is on energy savings. However, these savings are well below what is possible and typically will not be sustained. An EMIS should operate in real time for the following reasons:

- Real-time data can provide a better understanding of historical operations.
- Real-time data can produce better targets (models).
- Real-time information is better for activity-based costing.
- Real-time energy data is consistent with data collection to manage general process performance
- Identifying poor performance quickly allows staff to correct the problem and achieve energy savings through real-time monitoring and data analysis.

The OLAP system provides flexible reporting and analysis tools for strategic analyses and decision making support. The different types of graphs and reports are generated as per the requirement to support the real time decision support for energy management.

VI. Energy Graphs & Reports

Effective energy reporting is an essential element of a successful Energy Management Information System (EMIS). Reports are required for a range of individuals and departments, from operations personnel to the CEO in an organization. Each report must include relevant information in an easily understood format and all data should be consistent.

The reports must provide information to enable the user to act. Operational staff needs to know when a problem has occurred and what they should do about it. Senior management, on the other hand needs total information to maintain all the systems effectively. In order to design reports, it is important to understand who needs reports and why. Existing reporting infrastructure should be used wherever possible. Graphical techniques can be used with company intranets and the Internet, and the Web can facilitate access to reports anywhere, anytime.

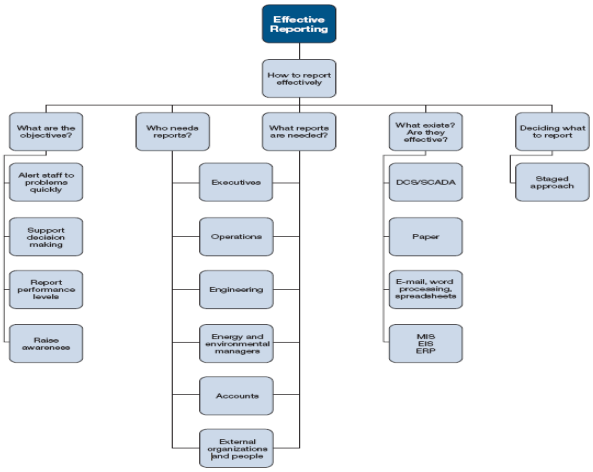

Fig 4 Block Diagram for Effective Reporting

The EMIS should include effective performance reporting to relevant personnel. This is to

- Ensure that staffs are alerted to problems in a timely manner
- Support effective decision making
- Report performance levels internally and externally
- Raise awareness and win support for energy Management Initiatives

A comprehensive EMIS will be targeted to a range of individuals and groups at various levels of Energy Management.

Reports will differ for each user, but all should contain relevant sound data regarding actual process

Data presented in reports must be consistent, and often it makes good sense for all reports to be available to all staff. However, the reports designed for each user should be limited to what he or she needs in order to effectively act. Ideally, reports should be readily available wherever and whenever these are needed. A Web interface made available on the corporate/company intranet/network can be highly effective.

As a rule, reports should be tightly integrated into existing performance monitoring and management systems. For

example, if operations staff relies on SCADA systems for information, display the results using these systems. If executives have an Executive Information System (EIS), it can be used to communicate the results. Similarly, corporate energy Web site may be highly helpful.

Moreover, energy reports should be subsets of general performance reports. Energy is seldom, so, the sole improvement objective should be considered with other factors such as output, quality and reliability.

By using OLAP engine we can generate the latest reports on minute wise from different source systems. The real time data acquisition system will extract the data, transform and loads the data in to different data targets.

The following are some reports generated by extracting the data from different source systems as per their requirement

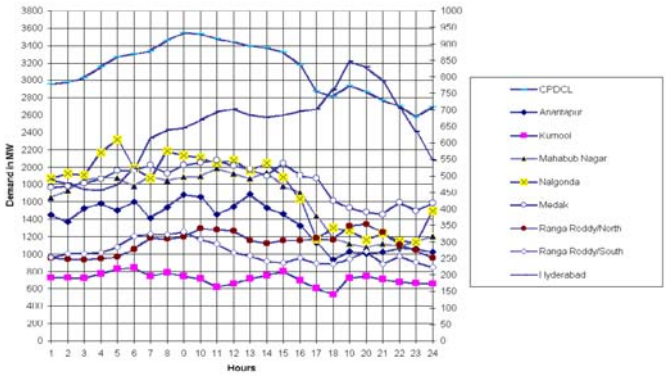

Fig. 5 Graph for Circle wise Hourly Demand in MW on 21.02.08

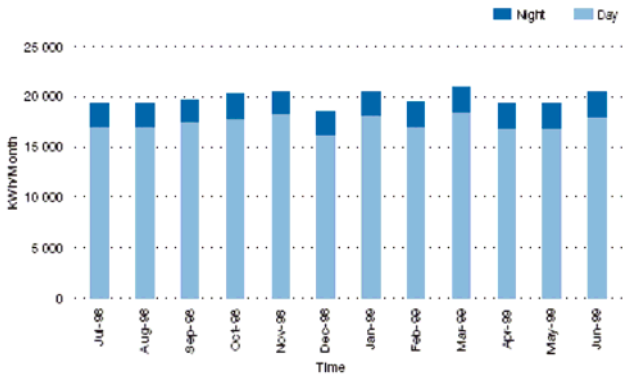

Fig 6 Monthly breakdown of electricity use showing day and nighttime units

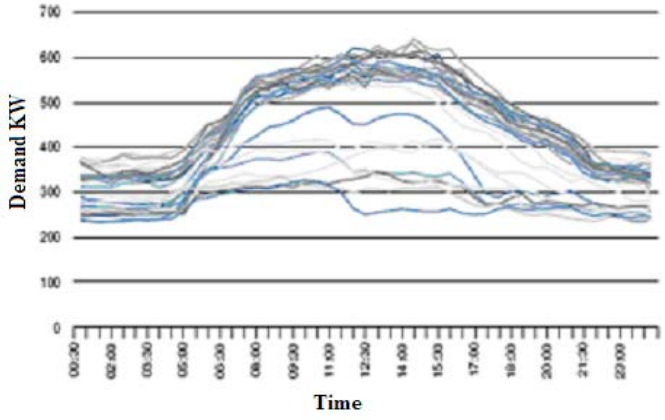

Fig. 7 Typical half –hourly demand Profiles (as a line graph)

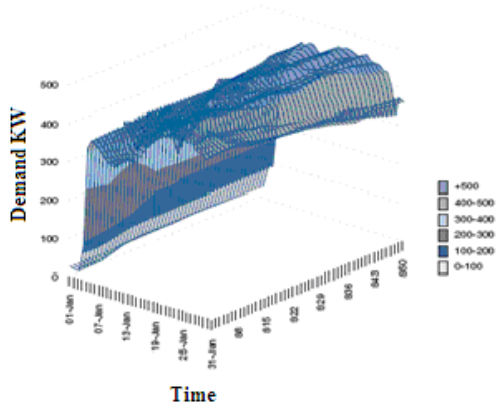

Fig 8 Typical half –hourly demand Profiles (as a contour plot)

VII. CONCLUSION

Fig 9 Block diagram for Energy Data Analysis

The following discusses the analysis of energy data and is a key section of this paper:

- Effective data analysis is essential but is often not given appropriate priority. Infact, poor analysis of data can destroy the operation of an EMIS and result in misleading messages.

- Energy data includes not only energy usage but key influencing factors also. Data must be collected at a higher frequency than any variations that are being studied. The objectives of data analysis are to better understand energy use and costs, calculate Performance levels, calculate targets and model energy use.

- The real time decision making can be done minute-wise by using the above Architecture.

- Integration of OLAP with SCADA and AMR, leverages modern computing capabilities to deliver highly actionable information to a wide range of users.

- Attempt has been made to simplify the activities of Electrical Utility companies by means of using a system that can retrive the complete information. Therefore optimization in operations, increasing work efficiency and improvement in business processes can be achieved.

- An advanced capability such as predictive analysis, simulation tools, contingency analysis and network monitoring makes the efficient utilization of electrical power.

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