Improving the Quality of Customer Service of Electrical Power Supply using an Integrated Outage Management System

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Abstract

An Integrated Outage Management System (IOMS) is a utility owned, centralized information system. Using the Supervisory Control And Data Acquisition (SCADA) methodology, the IOMS integrates different databases and components of outage management systems to improve the quality of service of electrical power to customers. This paper describes the development of an IOMS and its related utility functionality. The design considerations, salient features, component integration, functional aspects, and implementation issues of the IOMS are discussed. Evidence shows that the IOMS implementation would result in improving the overall quality of electric power supply and effective outage management significantly.

Key Words: Quality, Electric Power Supply, IOMS, SCADA, Customer Calls

1. Introduction

Quality of electric power supply has significant bearing on the customer satisfaction. Customer satisfaction is of utmost importance for the successful operation of electrical power distribution companies. It is desirable that power supply interruption, also known as outage to the customer is kept at minimum. However, electric power networks are subjected to faults, accidents and overloading which result in temporary outages. It is the responsibility of the utility to rectify these outages as soon as possible to restore power supply. Also, regulatory authorities specify standards [1] in quality of power supply in most countries, which utilities are expected to maintain. Utilities require modern, cost effective tools to manage the quality of power supply and also the related organizational functionality.

The process of outage management generally starts with a customer call and ends with restoration of supply. Customers contact the utility if they experience any problems related

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to the electric supply. Number of reasons such as a fault, low voltage, no supply can result in such customer calls, also known as trouble calls. Based on the information, utility will dispatch the crew to the corresponding location to service the problem. For a large sized system, complexity increases and hence better monitoring tools [2] are required to ensure quality of outage management activities. Poor quality of outage management can results in reduction in revenues and also in customer base. Most developed countries use independent call centers, which work independently from the utility, to manage these customer calls. Transmitting information from one source to the other is one of the major activities of outage management, for which utilities have to depend on automated outage management solutions. Several distinct advantages, including the improvement of overall quality can be realized, if all the activities related to customer calls, maintenance, rectification of the outage are properly integrated.

2. Utility Expectations and Design Constraints

Every utility usually will be having its own outage management strategy depending on its technical, financial and other operating conditions. As part of outage management, utilities manage information in several databases in several formats. Technical information like network connectivity, status of circuit breakers, meter readings will be available in Supervisory Control And Data Acquisition (SCADA) system. Generally, a SCADA system is propriety in nature with its own database. The information on customer calls will be available with the servicing offices, which may have their own databases. Customer information will be available with revenue/commercial section of the utility. Outage management requires the integration of all such different databases for obvious reasons to ensure effective operation. However, it is expected that the automated outage management solutions [3] to use the existing databases without modifying them. Such solution should be simple, highly scalable and yet cost effective. Also, compatibility and seamless integration with standard third party components should be supported. These conditions are taken into consideration while designing the proposed IOMS which is presented in this paper to improve the quality of utility operations in outage management.

3. Proposed IOMS

The IOMS is a centralized information system that is based on a common data warehouse which integrates different utility databases. This system intelligently deals with customer phone calls and network data to identify the cause of problems that exist in the distribution network. The suggested IOMS thus has an integrated data warehouse [4], which extracts the data from different sources; viz. Geographical Information System (GIS), Geographical Positioning System (GPS), Customer Information System (CIS), Work Management systems (WMS), Electrical network database, and data obtained from SCADA System. The data items in different sources are merged, analyzed, summarized and then the required information is transferred to the centralized data warehouse. Data in the central warehouse will be updated on regular basis from the individual data sources. Highly summarized data and important data conclusions are transferred back to specific areas of the warehouse. The proposed IOMS along with important databases and functional components is shown in the Figure 1.

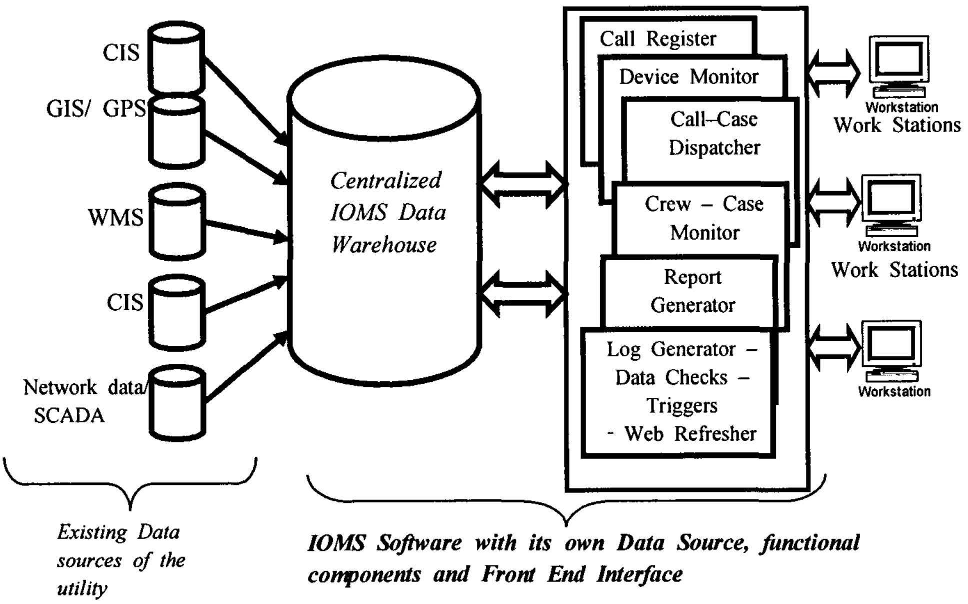

Figure 1. Schematic diagram of a proposed IOMS

IOMS is a well organized and centrally coordinated facility, owned and operated by the utility. Every customer call is registered based on the information provided by the caller. The call information includes nature of problem, reported time of problem and the time when problem started. The concerned officer will dispatch the crew to the location of the problem to rectify the problem. The information on successful rectification of the fault will be passed back to central office and the operator closes that trouble call. This completes the process of a trouble call. Some calls take a shorter time for rectification whereas some take days altogether for various reasons. It can be observed that if this process is automated, utility gets benefited in many ways besides gaining the customer confidence. Hence a well-designed, integrated database with user-friendly interface [5, 6] is essential to handle this problem. It is always desired that deployment of new software or any automation tool should be able to use the existing resources without affecting the system. Deployment of IOMS does not require any changes to existing system.

4. Salient Features of IOMS

4.1 Call Receiving

A powerful Graphical User Interface (GUI), which works on top of IOMS data warehouse, is designed to assist operators, dispatchers and engineers. On receiving a call from a customer, the operator asks few questions to identify the customer i.e., customer identity (ID), address and type of the problem etc. A highly interactive screen, known as 'registration screen', to locate the customer who is on the line, displays the important details of the customer. A dynamic search facility helps operator in locating the customer, based on other details like name, address and location etc, in case the customer is not able to provide the customer ID. Then, the software automatically links the customer to the appropriate substation, feeder name, the distribution transformer (DTR) and electrical pole number along with the device status using the dynamic information from network data obtained from SCADA. Sometimes, a "non-customer" may telephone and pass on the information about blowing up of a DTR. Such calls are known as device failure calls and will be given top priority automatically.

4.2 Call Registration, Priority and Response

Every call will be registered based on the details provided. IOMS provides the information if there is a known reason for outage for that customer. The reasons could be scheduled maintenance, load shedding, road accident or even non-payment of bills by the customer. The same information will be passed on to customers. Each call is given a unique number with the help of a specialized algorithm. If IOMS is not able to find a reason for the outage from the database, it will be treated as a call to be attended and appropriate priority will be assigned depending on the type of customer, type of problem etc.

4.3 Types of Calls

All received calls will be analyzed automatically for grouping and categorization. Grouping will be done in a device wise, area wise manner, while categorization will be done in terms of priority. For instance, if more than 20% of the customers from a particular device register their calls, that particular device will be declared as 'failed' and specialized crew will be dispatched to handle that device. All calls on that device are grouped together. Calls are classified as Individual calls, Group calls, Device failure calls. Calls from a certain area or on a specific device are grouped together with the corresponding area code. Group calls are given priority than individual calls as many calls can be closed by attending a single major fault. Major equipment failure calls are given highest priority as more customers over large area are affected and if the same is not attended in time, utility may lose revenue due to higher outage time.

4.4. Case Creation, Processing and Tracking

After grouping and categorizing the calls, cases are created for all calls. For a group call, a single case is created. Each case is given a separate ID for easier handling and dispatched to the respective field offices for dispatching the crew. These cases are then monitored for the progress of rectification. Based on the information, the crew with necessary equipment reaches the spot and rectifies the fault. Crew members communicate with the IOMS to inform on their arrival time to the spot, type of fault, reasons to rectify the problem and time of rectification. If the crew requests power shutdown for rectifying the fault, this has to be approved, as many customers will be affected, which means more calls to the center. For all such customers, the reason will be communicated. From this, it is clear that the field information reaches the IOMS and then customers are provided with updated information on probable restoration times, whenever they contact the utility.

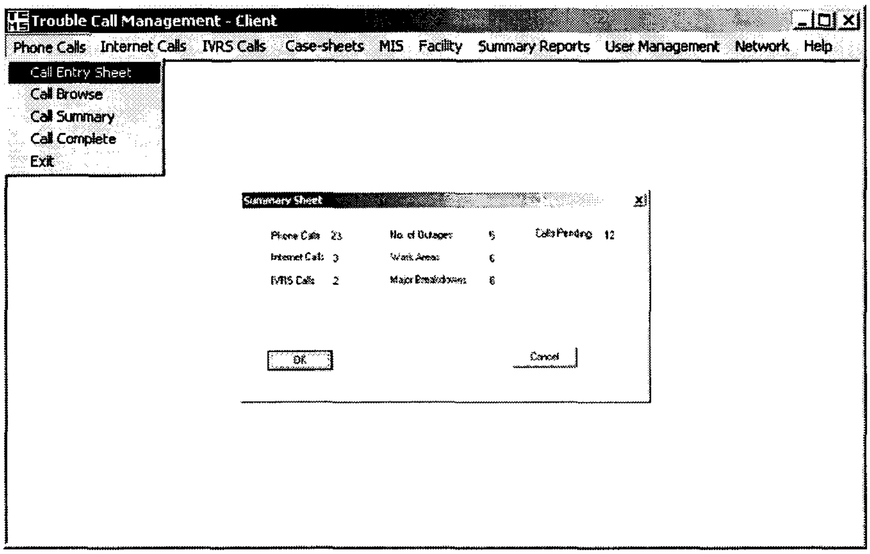

Figure 2. A summary of Calls and Outages

4.5 Status of Calls and Summarized Information

The summary of all calls, outages and work areas are displayed as shown in Figure 2. Status of each call is provided with all events, right from its registration to the time of completion. If any device is switched off, SCADA database is updated automatically and the same information is essential for managing the incoming calls. Hence, a link is provided between all databases and IOMS data warehouse to ensure periodical synchronization.

4.6 Call Closing

A call will be closed if the power is restored completely to that customer. This information is obtained from the crew on a given case. In the case of a group-call, this will be treated as closed if that case is completed. For the priority customers, a confirmation call will be made before closing their calls. This process is called 'Call Close'. The closed calls are then transferred to the data warehouse with a tag-'old calls' or 'historical calls'.

4.7 Report Generation

Customized reports based on the requirement are generated. These reports are presented in hypertext screens with good navigation support for quick and easy use. Reports provide valuable information like pending calls, device failures, major breakdowns, frequently interrupted customers, total duration of outage etc. Based on this data a utility can easily know how well is the quality of service offered. It is also possible to calculate the distribution reliability indices from the information provided by the IOMS software layer. Furthermore, all the devices can be tracked and their operations are logged. Device information is provided by area

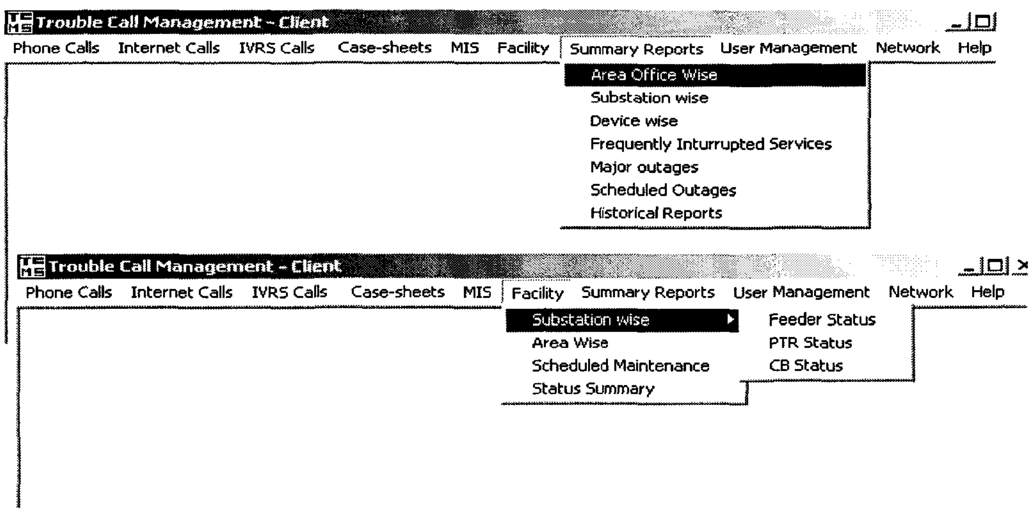

Figure 3. Report generation and facility monitoring screens

-wise and/or substation-wise modes for easy navigation. This helps utility to undertake necessary preventive maintenance activities, wherever necessary. Hence, this information is critical in ensuring the quality operation of network apparatus. Figure 3 shows the different ways of tracking the devices using the software.

5. Functional Components of IOMS Software

5.1 GUI and Data Access

The IOMS software layer is divided into a server edition and a client edition. Client edition configures itself differently for operator and dispatcher. Operators will be able to access only the required part of the information. Dispatchers will be able to access more information. Administrators can modify vital information of customers (such as address, phone number, etc) through the respective screens of server edition. Server edition automatically tracks for data consistency, user rights and other general software related maintenance aspects.

The GUI of the client edition consists of object oriented components like 'Call Register', 'Device Monitor', 'Call-Case Dispatcher', 'Crew-Case Monitor', and 'Report Generator' (as shown in Figure 1). These components are integrated with one another so that they essentially function on same data source. Each operator or dispatcher is given a specific employee ID. The ID is linked with the call that is received and processed by the individual. This helps in identification and verification of call processing and transactions. The information of the field teams and members of the team present on a given day will be available.

A powerful information system is developed for managing the details of offices, staff and crew members of the utility. This incorporates reporting relations, work assignments, availability of staff, contact details etc. Similarly, a facility management component, which includes the history of events of devices (including the maintenance, failures etc), is developed. Network Management component allows the tracing between a given customer and his substation through his pole number, DTR no, feeder number, circuit breaker, power transformer (PTR) number etc. It also generates a single line diagram from the network database in the absence of GPS and GIS data.

5.2 Data Entry of Customer Details and Editing

Sometimes, a customer whose details are not in CIS database may register a call. Calls from such customers are registered under non-customer category. Crew members would get the required details of that customer while attending the problem on a specific data format. Provision is made for such entries so that they are inserted into the database. At a later point of time, the data warehouse and the CIS database will be synchronized after a thorough inspection.

5.3 Internet-Based Trouble Call Management

With the advent of modern technology evolution, utilities are expected to provide on-line registration for troubles calls by their customers. A separate functional component is developed and integrated with the software. A customer will be given with a detailed screen to register the complaint online. This information will be registered into the IOMS central database. The major advantage of having this component is publishing the outage information on the web. This information contains major power shutdowns, scheduled maintenance, locations experiencing outage currently and expected restoration times etc. With this the number of customer calls would be greatly reduced.

5.4 Use of Geographical Information

The electrical network is represented in the form of a vector map and is superimposed on the raster map to create the necessary GIS. Different colors are used to represent the devices on which calls are pending, failed devices, healthy portions, dark regions, islanded network areas etc. With this, it is very easy to identify the area and an appropriate decision can be taken while assigning cases to crew. With the increasing popularity of GPS equipment, even positions of working teams in the field can be tracked.

5.5 Analysis

Network analysis programs will be running continuously, to indicate voltage profile of the network and screen is refreshed automatically to indicate low voltage sections. With this facility, operators will have clear idea of the network areas having overloading. A call from a customer incident to such sections can be answered effectively. Frequently failed devices/ locations can be studied from the old data. If a location is experiencing frequent faults, a manual inspection of the network will usually be undertaken in advance, to estimate the maintenance or replacement work involved. This helps in rehabilitation of the expensive network devices, which means saving the utility from serious and complete breakdown situations.

6. IOMS Design Considerations

Scalability, compatibility and inter-operability are given importance in overall design of IOMS. The detailed design aspects [7, 8] are out of scope of this paper and only few important design aspects are outlined. The data items are classified into three major categories:

a. Master Data
b. Transaction Data

c. Historical Data

Master Data has the information like frequent and standard types of outages, the fault rectification times, details of crew members, specialized equipment and its location. Transactional data consist of call processing, network changes and case progress. Historical data consist of old calls, log events and outage durations.

The IOMS software layer is designed in such a way that it integrates all the functional components and resources. In case of absence of any component or data, the software automatically reconfigures itself. For example, the built-in single line diagram generator produces the vector map in the absence of GIS or GPS data. This makes the software highly scalable, economical [6] and hence reduces implementation time. In fact, the design is based on the implementation issues. Some of the factors which influenced the design include phase wise implementation, complexity of network, utility constraints and integration with third party components.

7. Integration with Third-Party Components

IOMS is so designed, that it can be readily integrated in a seamless fashion with third-party components [9] to enhance its functional quality. The core third-party components that can be integrated with IOMS are discussed below.

7.1 Automatic voice response systems

Adopting automatic voice response systems (AVRS) is a modern trend in customer relation management and already in use in various sectors. These systems can be effectively used to register outage calls even in the absence of control centre operators. Any standard third party AVRS component will have the software interface and updates a specific table of given database. Similarly, Short Message Service (SMS) gateway-based complaint registration can also be facilitated, with which customers will be able to register the complaints with cell phones. Once, complaints are entered into the proper database, IOMS translates appropriately, so that complete information is available to users.

7.2 Auto Outage Detection/Reporting Systems

Highly intelligent devices like load monitors, load managers and fault locators [10] are available. These devices are integrated to SCADA using standard interfaces and send the signals in case of overloading or faults. IOMS recognizes these database changes automatically and operators will be given alerts accordingly.

7.3 Computer-aided modeling of crews

Work Management systems are used for the computer aided modeling of crews of the utilities, as a standard practice. The proposed IOMS has a prototype WMS which is necessary for the operation. IOMS would adopt the functionality of a third-party WMS component by proper integration. Crew capabilities, tools, equipment, availability etc are modeled using object-oriented concepts. Analysis and presentation of this data provide a better perspective for the operators to take quick decisions. Real-time location tracking of crews is possible with using GPS technology. In the absence of a third-party WMS component, IOMS operates with its own modeling of the crews. This demonstrates the scalability of the IOMS.

8. Use of IOMS Data

The data of IOMS can be readily used to find the reliability worth of a power utility. Investments related to provision of service reliability needs to be carefully evaluated in regard to their cost and benefit implications. In addition, utilities are recognizing the significant and community costs that are incurred when electric supply is abruptly curtailed. The reliability worth index is termed as the interrupted energy assessment rate (IEAR) and is obtained by relating the reliability indices to the customer cost of interruption data (see Equation 1).

$$SystemIEAR = \frac{CAIDI \cos t}{CAIDI}(\$/kWh) \cdots\cdots\cdots\cdots\cdots\cdots \text{ Equation 1}$$

Customer Average Interruption Duration Index (CAIDI) in hours can be calculated from historical data of IOMS by summing up the duration of all interruptions over a period. Based on type of customer and corresponding cost of energy (i.e., available in IOMS master data), the cost of energy over interruption duration is calculated. As the data is available in tables, this computation can be done dynamically using sequel scripts, whenever required. As the device outages and scheduled maintenance are also available, IOMS data gives more realistic estimation of IEAR than any other computation model. From this information, utility can take executive decisions on the issues like reconfiguration of power networks to improve the quality of power supply, expansion of their operations, and unit price of power supply.

9. Conclusions

An efficient methodology for creating a centralized facility to overall quality of power supply is suggested. A data warehouse which integrates the existing data sources of the utility is developed. A highly interactive GUI which works on top of this warehouse is also presented. The new deregulated environment of the electric utility industry and the resulting customer choice programs motivate this initiative. More detailed knowledge about the nature of outages will improve customer relations and a faster response time to outages will improve quality of service by reducing outage times. These two key issues are expected to increase customer satisfaction and allow utility to retain existing customers and attract new customers.

IOMS data can be effectively used to determine the reliability worth of a power utility and can be used to distribution planning and design by incorporating the economics of reliability in decision-making process. IOMS is highly scalable depending upon the requirements of utility. Important data tables are made transparent to ensure compatibility and integration with third-party modules (like AVRS, WMS etc.).

Moreover, analysis of log files, historical reports generated by IOMS helps in identification of frequently failing devices, ill-conditioned network elements and also dissatisfied customers. The maintenance of the costly and aged equipment can be well planned from the knowledge acquired from the IOMS log files. It can be shown that utility gets benefited in many ways especially in improving the quality of electric power supply with the implementation of the suggested IOMS.

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