Wireless AMR system for restoration confirmation using general polling algorithm

Mr.Naveen B M, **Mr.Deepak Salian**, **Mr.Raghu S**

***Abstract*— The demand for electricity is continuously increasing even if the distribution system affected severe faults by some environmental factors. For handling of these outage problems in distribution system, high quality Automated Meter Reading (AMR) systems are developed, which provide more metering information about the status of the distribution system. Therefore both utility and the consumer have to mutually interact to utilize optimally the available electrical energy for the mutual benefits. AMR is the remote collection of consumption data from customer utility meters over wire or wireless communication links. AMR systems are generally perceived by power utilities to offer many customer services as significant benefits to customer. Because of the rapid industrial growth, there is a considerable rise in demand for electrical energy from various categories of consumers. In the current scenario, we are facing the difficult tasks of matching the availability with the ever increasing demand. In this paper, an attempt is made to highlight how to locate the exact outage locations and service restoration confirmation by using the real time data which are collected from the *AMR systems* associated with *Trouble calls* and *Supervisory Control and Data Acquisition (SCADA)*. An attempt is being made in developing a meter polling algorithm for the escalation procedure which involves pinpoints exact outage locations and the restoration confirmation based on the meter polling results. By implementing this work, efficiency of electrical energy utilization in customer level can be improved to a considerable extent. The customers have benefits like high operational efficiency, maximization of profits and reduced cost. The utility is benefited by the saved energy, improved load factor, reliability of power in the distribution system and the overall benefits to the society as a whole. In the present work, a new algorithm has been developed for distribution system restoration confirmation and the results have been evaluated for the 44-bus system. In this paper, the solution largely depends upon selection of ranking of the meters and meters Packet Success Ratio (PSR) and the results have been found to be very much satisfactory by adopting the meter polling algorithm.**

***Index Terms*— AMR, METER POLLING ALGORITHM, SCADA, PSR.**

I. INTRODUCTION

Electrical power is the main driving force for human and social development. Further, it is a major energy source used widely in the community because of its flexibility in its operations, and its ease of application..

It is an efficient, versatile, convenient, safe, secure and pollution free source of energy. So, the electrical energy will be an essential component for achieving the goals for sustainable development to satisfy the customer energy demands for sustaining and developments, balance the generating and the distribution energy by adopting renewable energy and protection of electrical systems when the system gets affected by faults during some severe environmental factor. Service restoration planning is to find appropriate backup feeders to restore the outage area load.

In case of a large-scale distribution system, its solution space becomes huge due to a large number of switches, so the analytic method for solving the problem can hardly be applied. In this attempt the distribution system restoration is important tool as well as a real time control tool in the outage management system, for meeting the customers demand after the fault affected the system.
Several studies have indicated that there exists number of potential methods which are improve in the protection of electrical utilities in the distribution system by adopting Meter Polling algorithm.

The automated meter reading systems are installed at the customers level, helped the utilities gain access to consumer consumption data, power quality in the system and real-time outage notifications when we need, these data supplement customer calls. In the entire distribution system, no single source which does not provides enough accurate information about the system status during outages by some severe environmental factors. So by using the trouble calls, SCADA and AMR systems with real-time data notifications, the meter polling procedure implement to confirm the outage locations and system restoration of the distribution system.

Methods have been developed for finding out the outage locations and service restoration problems by employing fast outage tracing and the meter polling algorithm techniques. G. Moon, B. H. Cho, H.M. Park, H. S. Ryu, Bok-Nam Ha and Sung-II Lim [1], develop a fault restoration algorithm using fast tracing techniques based on the tree structured database in the distribution system. R. Fischer, N. N. Schulz and G. H. Anderson [2], they shows how AMR systems are managed the information which is obtained by the distribution system. Y. Liu and Noel N. Schulz [3], shows how the integrated outage information filter which is used for distribution outage information using intelligent method. Emmett Kelly [4], explains today's changing industry by using the AMR should have place in system. R. Fischer, A. Laakonen and N. N. Schulz [5], practically derived the service restoration and its confirmation in the distribution automation system by using AMR meter polling algorithm. In [6] and [7] Y. Liu, Krishna Sridharan and Noel N. Schulz, they explained using an

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intelligent data filter for outage management through AMR systems.Y. Liu and Noel N. Schulz [8], build a knowledge based system for distribution system outage locating using comprehensive information. In [9] P. Jarventausta, A. Makinen, K. Kivikko, Timo Chrons, P. Trygg and S. Vehvilainen, describes the low voltage distribution network management using advanced AMR systems for the reliability of operation in the distribution system network. L. Xu, M. Y. Chow, and L. S. Taylor [10], determines how the data mining and analysis of tree-caused faults affects the system in distribution network. In [11] R. Srinivasa Rao and S. V. L. Narasimham, develop a new heuristic approach for the network reconfiguration for the system restoration in the distribution system. Deepak L Shenoy and Suresh Kumar from EASUN REYROLLE Ltd., Bangalore, explain how the AMR Data contributes on Distribution system operation"

II. PROBLEM DEFINITION

The Automated Meter Reading systems are installed at the consumer levels helped the utilities gain access to consumer consumption data, power quality in the system and real-time outage notifications. These data are supplemented customer calls. In the whole distribution system, *no single source which does not provides enough accurate information* about the system status during outages by some severe environmental factors. So by using the trouble calls, SCADA and AMR systems with real-time data notifications, the meter polling procedures introduced to confirm the outage locations and system restoration of the distribution system.

The Automated meter reading is the powerful device which collects the remote information about the consumption data from the customer utilities. The electrical utilities are exploring the use of AMR data for the filters for distribution system for locating specific functions. The signals which are coming from AMR system provides the additional information for the locating the outages and the restoration processes. However, the AMR system with low quality, information not feed directly to the outage management system. The Filters which are used in the system to removes the false outage notifications that are getting from the Automated Meter Reading systems.

An outage Management system is the major component in the distribution management system. So, an efficient fast outage tracing technique is used for pin pointing the outage locations Before the sophistication of outage locating procedures introduced, locating the outages in the distribution system is done by the human excellence experiences. When it combines with computer system builds the knowledge-based system with available comprehensive information. The fast outage tracing procedure is adopting the left child/right sibling tree structure data base [1]. The features about this techniques are i) fast outage network tracing, ii) convenience in the system data management and iii) convenient and fast notification of the system data due to some network changes.

The outage locating and the restoration of system are the problems in outage management system in distribution system. The main objective of the outage management system includes data which are collected through customers level trouble calls, SCADA and AMR. The customer trouble calls are widely used for outage management system.

The SCADA provides the system operational information and the status of the system monitoring, which is the supplementary source to the trouble calls during outages. Using the automated meter reading systems for the outage management application is a new type of technique currently under developments. A summary of project work developments is provided in the following sections are;

- Locating the outages
- Fast Restoration Algorithm and
- Meter Polling Algorithm

III. AUTOMATED METER READING SYSTEM

a. Introduction to AMR System:

Automatic Meter Reading (AMR) allows for an increased understanding of energy consumption on a near real-time basis. AMR allows energy prices to be substantially reduced by eliminating 'estimated billing'. It is conservatively estimated that 2% of annual energy costs can be saved by installing AMR. With subsequent demand side management this can increase to as much as 15%. Currently most buildings have general electricity meters, which need to be read manually, meaning that they are often read irregularly. If the electricity meter would either be replaced by a 'AMR' meter which can increase reading frequency and billing accuracy.

As part of the KPTCL Projects, **Buying Solutions** is committed to taking the lead role in the procurement of Automatic Meter Reading and related services. The resulting framework will be available to the whole of the public sector and will facilitate a flexible menu of options allowing customers to tailor the solution that best fits their needs. AMR provides the means of ensuring sufficiently robust data.

b. Necessity of AMR:

- Improve reliability and accuracy of data.
- Improve system reliability.
- Improve billing accuracy.
- Provide more accurate load data.
- Reduce power system failures.
- Eliminates estimated meter readings.

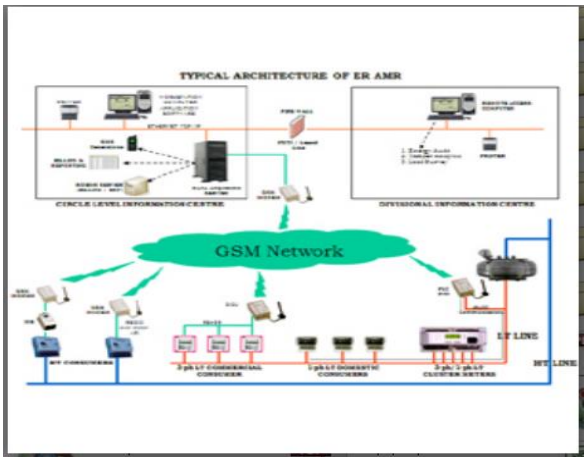


Figure 1 A typical AMR system architecture

c. Communication Network of AMR System:

The figure 2 is the communication Network of AMR system with Distribution Management System or Supervisory Control and Data Acquisition (SCADA) via Gate ware data base of the distribution system. The advanced AMR meters which are installed at consumer levels. When there is violation, which crosses the limit which is set in the Data Base gives alarms signals to SCADA or DMS. The power monitoring of the distribution system is also update the information in to the Data base.

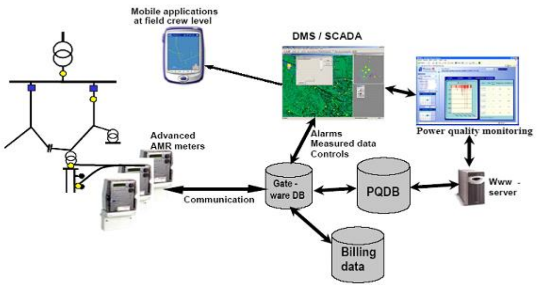


Figure 2 Communication and Data monitoring AMR system

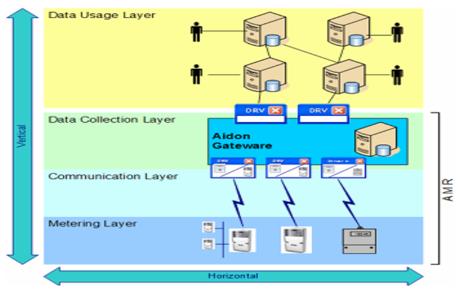


Figure 3 Layer wise function of AMR system

The figure 3 shows that how the Automated Meter Reading (AMR) system is communicated with metering, communication and the data collection layers in distribution automation system.

d. Information Management of AMR:

Metering technologies and communications systems have advanced to enable the development of Automated Meter Reading (AMR) Systems. These systems are being used for billing, maintenance, and outage procedures. These new meters provide a wealth of information that needs to be understood, but a utility must learn to manage all of this information to fully benefit from an AMR system. Flags passed from the meter or its controller can include information to specify any changes in status, errors, or other abnormal functionality. With all of this data the key to being able to take full advantage of an AMR system is to understand and properly use these flags to effectively implement a meter maintenance process, respond to potential tamper situations to avoid lost revenue, and efficiently dispatch field crews responding to outages.

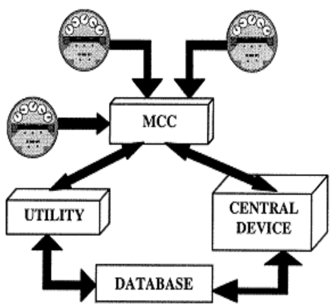


Figure 4 Path of data from meter to utility

The automated meters being used by KPTCL are either used mechanical meters retrofitted with a communication meters built for use in the distribution system. The meters send packets of information using radio frequencies to a microcell controller (MCC) [2]. The controllers then send the data through other central communication devices, referred to as Cell Masters. The Cell Masters pass the data on and populate a database. The database is then made available for the utility so that all data from the AMR system can be evaluated. Figure 4 shows the path for data from the meter to the utility. The meters send packets of information to the MCC every five minutes. Since there are a number of meters on each controller there is the possibility of packet collisions. In order to avoid this, the packets are randomized over the time period, such as five minutes for normal packet delivery. Within this packet the meters can send information regarding cumulative usage data and any problems that it may have.

Once the MCC receives a packet containing an error condition it sets a flag for that meter to show the given problem for the day. The final read of the day, which includes these flags, is placed into a database to insure that no data is lost. These flags are then reset at the start of every day. The flags can then be looked at daily by the utility to determine if a problem still exists or was resolved.

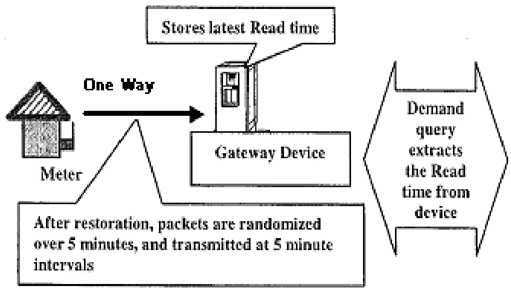


Figure 5 Overview of Packet randomization process

A utility can also communicate directly with the MCC by doing an on-demand read. This allows the utility to ask the MCC for the most recent information received from the meter in question. The data returned using the on demand read is of very high quality. This process can be used to confirm outages and restoration and determine the state of the service.

e. Benefits of Networked AMR meters:

Consumer Friendly: Consumers can get essential information such as payment dues or their unbilled amount as and when required.

Monitoring Electrical Parameters in Real Time: The various transducers monitor the real time data and gives alarms when the system which effect by some faults.

Minimizing Technical Losses in Low Distribution: By monitoring power factor and harmonic currents, problems areas are identified then action is taken to minimize the losses.

Resource Activation: The network allows the utilities to control the resources as per load conditions.

Online Audit for Pilfer Detection: The consumer meters communicate online with the main audit meter located up streams usually at distribution transformer side, this helps to detect theft and pilferage of energy when attempted on odd hours.

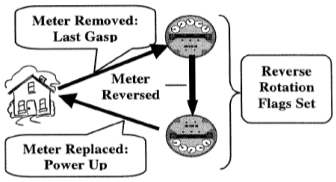


Figure 6. Flags movement to identify tampering

Soft Shutdown: The network is sheds, when the system is under abnormal condition.

Common Infrastructure for All Services: The networked AMR will merge with concerned services to unified system to monitor electricity supply, outage escalation process and system restoration confirmation using common network interface.

f. Applications of AMR Systems:

The below figure 7 shows some of the applications of AMR systems including infrastructure, the managing function, information reporting features, network and power monitoring management in the substation.

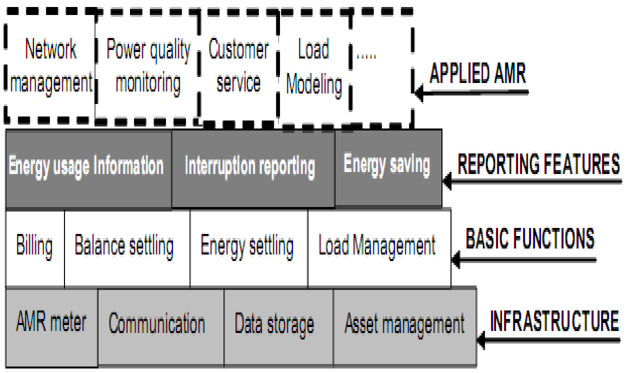


Figure 7 Applications of AMR system

IV. PROPOSED ALGORITHM

Outages of the electric power system can cause problems for utilities and their customers. Prevention of some outages can be accomplished by replacing outdated equipment. The meter connection is the most direct link to enhance the relationship between the customer and the utility. The meter can become a gateway for multiple service providers and provide real time information [5].

Restoration of distribution systems is a complicated process, especially after storms, when a large number of outages can occur. Many utilities are implementing Automated Meter Reading (AMR) systems that can aid in the restoration process. This presented project work done to utilize the capabilities and information provided by a wireless AMR system, including the on-demand read feature, to develop a polling procedure to identify system conditions. It takes advantage of the connection information provided by a utility and the performance of the wireless meter communication systems.

Metering technologies and communications systems have advanced to enable the development of Automated Meter Reading (AMR) Systems. Utilities have a substantial investment in AMR systems and need to develop applications that extend beyond billing purposes. Outage management is one area where the AMR system can be very valuable. Most utilities rely on a trouble call system where customers can report outages to the utility. These systems make it difficult to find multiple outages on one section of a network and to confirm restoration of all customers downstream of a fault. Cascading outages occur mainly in large storm situations and can lead to a utility unknowingly leaving customer without power.

The automated meters can be polled to determine their power status at any time, but in large outage situations, it would not be efficient for the utility to poll every meter in the affected area of the network due to time and data constraints [6]. This project work represents a general polling algorithm to be used in confirming restoration using a wireless AMR system without polling all of the meters in the network.

a. Polling Algorithm:

The wireless communication systems are used by the AMR systems for polling algorithm. The polling process employs an on-demand read procedure that allows the utility to communicate with the controllers and determine the status of a meter. The utility cannot communicate directly with the meter itself because the communication from the meter to the controller is only one-way for the system used as the basis for this work. A general polling algorithm has been developed to use this on-demand read feature during the restoration of outages. This algorithm uses a tree-based model of the distribution system to obtain information about the status of the system without polling all of the meters in the distribution network.

Once an outage is restored, the utility can look at the section of the network that had a fault and poll the meters that give the most information about the system, to aid in locating cascading outages. If a second fault has occurred below the original outage, the utility would be able to run the polling algorithm and spot customers without power.

Since each on-demand read could be time consuming, the utility would not be able to poll all of the meters, especially during the restoration process. The user of the polling algorithm can choose a desired stopping criterion ranging from a small percentage to all of the meters (based on the PSR values of the meters). The number of meters per transformer and the percentage can vary depending on the wishes of the utility. A time limit may also be used to poll as many meters as possible within a given amount of time.

For the purpose of the polling algorithm, the distribution system was modeled as a tree [5]. This model is appropriate for distribution networks as they are based on a radial structure without loop connections. The nodes of the tree can represent devices such as transformers and the leaves of the tree are the meters located at the customer services. As some distribution systems are weakly meshed networks, changes would need to be made to accommodate multiple paths to a meter. The algorithm would not apply to a completely meshed transmission network, as this algorithm is based on the use of meters located at a single customer service. Figure8 shows a simple tree to demonstrate the concept.

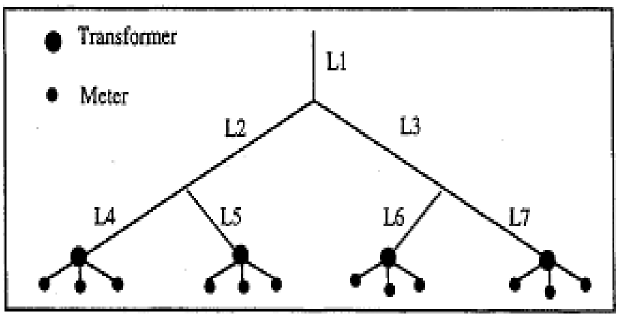


Figure 8 Tree representation of the distribution network

The algorithm must have specific data about the meters and their locations in order to efficiently poll the network in question. This data includes the *meter identification number,* the connection information, including the *transformer id,* and *the Packet Success Rate* (PSR) of all meters. The PSR of a meter is a communication performance index and is used to track the meter's ability to communicate with the controller. The meter's daily communication performance is tracked by recording the percentage of daily reports that are received. The PSR value is stored with other important meter information and is updated weekly. The *line ids* are also needed for the lines that connect the meter back to the top of the tree in question. Table 1 shows an example of the data needed for the tree, to polling algorithm.

Once an outage has been restored the utility can use the known location of the outage and can obtain the needed information for all meters below that level. The meters in that section of the network can be ranked by how much information they can provide about the status of the network. The PSR value is also used in determining the rank to give accurate results and as a tiebreaker when more than one meter can provide information about the same number of links. Equation (1) shows the rank of the meters is calculated by,

Rank = PSR* (number of links with unknown status) *- - - - - - - - - (1)*

Table 1

A sample data for Polling Algorithm

Meter Id	Transformer Id	PSR	Line Id1	Line Id 2	Line Id 3	Line Id 4
EW001	XFMR 01	85	LI	L2	L4	L8
EW002	XFMR 01	70	LI	L2	L4	L9
EW003	XFMR 01	95	LI	L2	L4	L10
EW004	XFMR 02	98	LI	L2	L5	L11
EW005	XFMR 02	69	LI	L2	L5	L12
EW006	XFMR 02	87	LI	L2	L5	LI 3
EW007	XFMR 03	86	LI	L3	L6	L14
EW008	XFMR 03	73	LI	L3	L6	L15
EW009	XFMR 03	51	LI	L3	L6	L16
EW010	XFMR 04	98	LI	L3	L7	L17
EW011	XFMR 04	84	LI	L3	L7	L18
EW012	XFMR 04	93	LI	L3	L7	L19

The meter with the highest rank is chosen and polled and all status information is updated. Initially, all meters and links are given an *unknown* status. The status of a meter reported to have power is yes but a meter reporting to be without power receives a status of *possibly out.* This is done because of the uncertainty in the wireless system. The meter may have reported a false outage or may not have reported restoration at the time of polling. Once this is completed the ranks are re-calculated based on the known information. This continues until the stopping criterion has been met. Once the polling is completed a list of meters without power area can be viewed.

A secondary polling can occur by taking all meters on a transformer with at least one meter reporting an outage and re-polling them. All meters whose status is *unknown* or *possibly out* can be polled again to confirm the level of the outage. If a meter has reported a *yes* status when more than one meter on that same transformer has reported an outage that meter should also be polled again. A list of all meters without power can then be viewed again. This list then could be put into the utility's outage management system where escalation could occur. Figure 9 shows the basic flow of the algorithm.

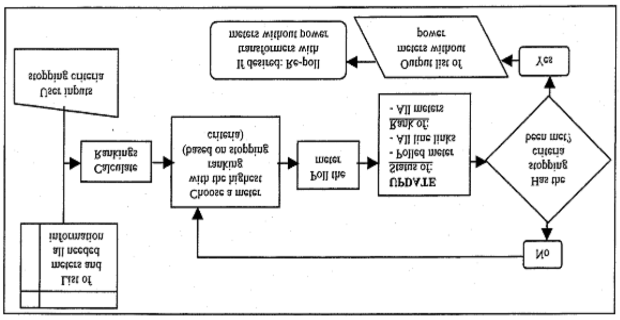


Figure 9 Overview of the Meter Polling algorithm

b. *PSR Modeling:*

The variation in PSR is complex and difficult to express in terms of a mathematical equation. Therefore it is difficult to define a rigid distribution for the PSR in terms of what values might constitute a low PSR value and what might constitute a high PSR value. This uncertainty in the PSR has been modeled using three fuzzy sets LOW, MEDIUM and HIGH.

1) ***Fuzzy Set LOW***: The membership graph of this is shown in Figure 10. Initially when the PSR is very low the membership value (μ) is high and as the PSR increases the membership surface follows a declining sigmoid growth curve [13].

2) Fuzzy Set MEDIUM: The membership graph of this fuzzy set is shown in Figure 10 and the models the fuzzy set MED. The membership surface has a symmetric PI (π) or bell-shaped curve. The concept of "medium" values is semantically equivalent to the concept of "some". The fuzzy semantic "some" is represented as a PI (π) curve centered at 50% of the range [13].

3) Fuzzy Set HIGH: The membership graph fig 10, models the fuzzy set HIGH. The concept of "high" values is semantically equivalent to the concept of "most." The fuzzy semantic "most" is represented by a sigmoid growth curve starting at 50% of the range[13].

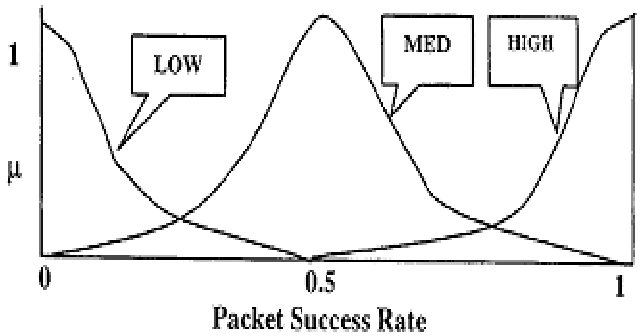
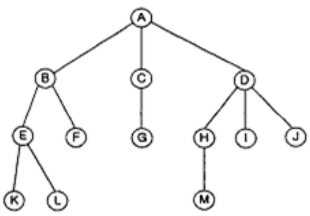


Figure10 Packet Success Rate with respect to membership value

c. Fast Restoration Tracing Algorithm:

The distribution system has the very complicated network configuration when it subjected into frequent switching on and switching off operations due to the fault clearing and service restoration process. For developing a fast outage tracing techniques we adopt the left child / right sibling tree structure for the data base [1]. This algorithm reduces the computational time drastically. The de-energized are due to some outages in the network can be represented by sub-tree of the entire network tree.



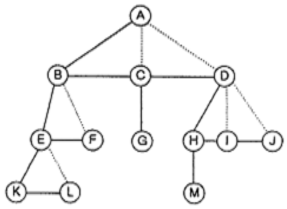


Figure 11(a) Original Tree System Representation

Figure 11(b) LC / RS

1. Left Child / Right Sibling Tree Representation:

The service restoration switching action can be taken on one of ending nodes of the network tree. For example, in Figure 12(a) showing below a simple distribution system for explaining reconnection of network. Consider the restoration of area 'A' which is de-energized due to a fault on a DL connecting SW35 and SW36. Area 'A' is denoted by a circle in Fig 12(a). Assume that the de-energized area A is to be restored by turning on the tie switch 16. Here, it should be noted that the power flow would be reversed by closing the tie switch 16.

We can establish the following sub-tree headed by SW16 by simple back tracking as shown in Fig 12(b). Here, it should be noted that the sub-trees 'B' and 'C remain unchanged, which makes the modification algorithm extremely simple. The modification can be completed by attaching the tie switch headed sub-tree to the restoration switch labeled with the same name.

The steps for the network reconfiguration in the de-energized nodes / sub-tree nodes are as follows;

Step 1: The procedure will begins with tie switch node with which the sub-tree should be restored. Let take that tie switch node as a reference node.

Step 2: If that reference node has its parent pair node, then that parent pair node becomes the child of the reference node.

Step 3: If the reference node has its next related node becomes next pair node of its parent's parent.

Step 4: Then the reference node is set to be the original parent pair node of present reference.

Step 5: Repeat the procedures from Step 2 to Step4 until the reference node become the sub-tree's last switch node of the de-energized area of the entire network

The Left child / Right sibling tree structure is a useful and convenient method to represent multi-branched trees. The following example figure 12(a) and figure 12(b) shows the structure of the tree.

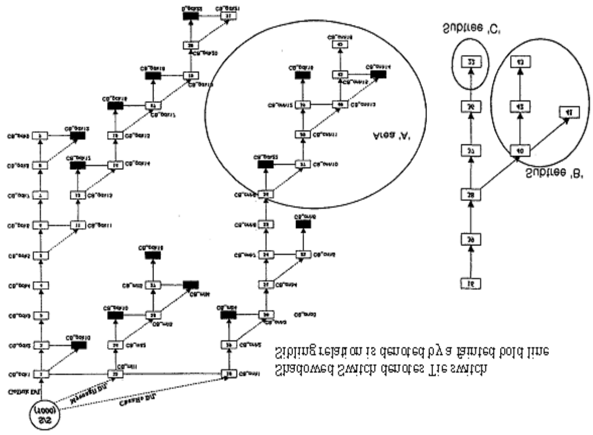


Figure 12(a) Network configuration of Left Child / Right Sibling Tree Structure and
Figure 12(b) Network configuration Tie switch headed Sub-tree

This algorithm adopts a method to store all the tie switch nodes to an array with the information of energized or de-energized nodes of the network. These selected candidates provide the basic information for the determination of the restoration switching. The restoration switching should be investigates under some system parameters such as limitations in the line capacities and the voltage drops at terminating nodes. It is also desirable to consider the following conditions i) minimizing the un-restored area ii) reducing the number of switching operations iii) minimizing the unbalance of the loading rates of the distribution line feeders. This solution search can be feasibly performed by using the candidate switches, if the faulted area is divided into many parts as the number of restoration switching.

The restoration switching action takes in single, double or triple switching restoration procedures. As detailed explanation by Y.H. Moon, B.H. Cho, H.M. Park and H.S. Ryu, the single switching restoration algorithm [1] as below;

i). Check for all the candidate tie switches in the sub-tree due to de-energized area, choose the P^{th} candidate tie switch be $S^{(j)}$.

ii). Check for the pair tie switch in the system tree configuration, choose that pair tie switch be $PS^{(j)}$.
iii). Calculate the load margin of the distribution line to which the $PS^{(j)}$ belongs for each $PS^{(j)}$.
iv). Evaluate the load margin with the amount of loads to restore. If the j^{th} load margin is less than the de-energized loads, $S^{(j)}$ is not taken into account from the candidate tie switches.

v). After getting the reconfigurable network run the load flow by closing switch $S^{(j)}$ From the results of load flow calculation, the switch where the maximum voltage drop occurs in the system can be identified.

d. Meter Polling Algorithm:

Many utilities in the system are implementing AMR system that can aid in the service restoration process. Metering new technologies and their communication system have advanced than the old mechanical meters to enable the development of AMR system. Some of the more developed applications are off-peak pricing, flexible billing, energy management system, reduced the cost in reading, maintaining and replacing meters and additional data during outages.

The most widely used method for outage determination is upstream tracing the network from the location of customer trouble call and identify the first common devices as the outage location called escalation process [14].

The automated meters send the packet of information randomly using radio frequencies to a Micro Cell Controller (MCC) in every five minutes avoid possibility of packet collisions [2]. Then the controllers send the information through the communication devices to the utilities and central device. Then this device builds the data base and updated when it getting the recent information using real-time read procedures. The flags from the AMR are sets when there is an error in packet otherwise if the information is not receiving by MCC. This process can be used in confirming the outages, restorations and determine the state of the system. The figure shows the overview of the polling algorithm.

The meter polling procedure is designed based on the on-demand read features of AMR to 1) Locating the outages 2) Restoration confirmation and 3) Meter Polling.

e. Locating the Outages:

Most of the traditional outage handling methods are based on the customer trouble calls [14]. The absence of the customer might prolong the outage location determination process and as the result will prolong the restoration action. The outage handling methods using AMR systems provide the utility an alternative way to access the customer information. However, the data transmission is a big challenge, which will directly affect the accuracy and flexibility of data information collection.

Holtom and Ponder gave an introduction of the automated metering technology at the 1999 IEEE PES Winter Meeting [8]. They presented mainly addressed the data collection issues of the new automatic meters. However, the quality of AMR can be low due to the problems associated with wireless signal transmission. In [6], Sridharan and Schulz developed an automated meter reading data filter. Their system uses fuzzy logic to model uncertainties during meter reading and filters raw AMR data to provide more accurate outage information for escalation algorithm.

The widely used outage handling methods in distribution systems use customer trouble calls to locate the outage [6]. With the development of distribution Supervisory Control and Data Acquisition (SCADA) in recent year, more system operation information can be monitored from distribution substations down up to customer levels. At the customer level, the installation of automatic meters has helped utilities to have access to consumption data, power quality data and instant outage data through the Automated Meter Reading (AMR) system. Even though these various data sources are available from the distribution substation to the customer, due to the complexity of the distribution system, none of these data sources can be consistently without error.

The new challenge is how to use these limited information sources efficiently to provide a better outage handling strategy. In this paper an integrated outage information filter is proposed to provide more accurate outage information, which utilizes the comprehensive real-time data from trouble calls, distribution SCADA and automated meter readings.

The main outage sources are Trouble calls, AMR and SCADA, this information fed into the filter gave the comprehensive information about the outages. This is analyzed by knowledge based system [8]. This will pin points the exact outage locations in the system. The filtered outage information has higher accuracy and low redundancy.

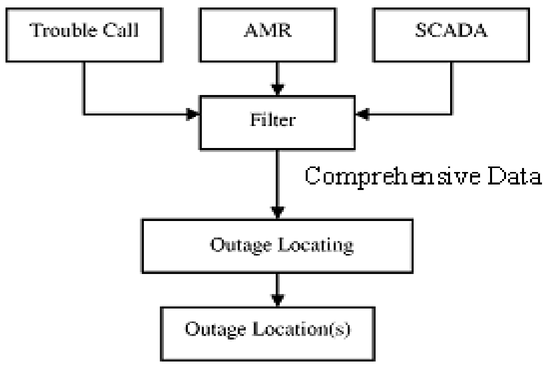


Figure13 Overview of the Outage locating process

The simplest and least accurate method is approach, requires the geographic location of the caller to be known but does not require the connectivity of the distribution network and location of protective devices. As a result, the location of the outage device cannot be determined [14].

The most widely used methods for outage determination are based upon upstream tracing from the location of the caller and identifying the first common device as the outage location, called escalation methods [14]. These methods provide decent outage determination results in the case of a single outage. The problem with escalation methods is that they assume that one device outage happens at one time. This is usually invalid during large outage storm scenarios.

Fuzzy logic is used in this algorithm to model the uncertainty of the outage information and to reconcile conflicting data. The filtered outage data include a reduced amount of accurate information for use in the outage location and system restoration algorithm.

A. Fuzzy Logic:

Electric power outages can cause economic loss for both utilities and customers. An Outage Management System (OMS) can provide utilities with a tool to provide better response for outages and restoration. The basic functions of an OMS include identifying the location of an outage based on the outage notifications and providing a technique for quick outage restoration.

The task of outage handling on the distribution level is different than on the transmission level. Most of the transmission system has meters or sensors installed, which can monitor an outage or status changes of the devices and report within several seconds. The distribution system is much larger and diverse so that an accurate and cost effective metering scheme currently is not available. The lack of measurements makes it much harder to determine the outage location accurately on the distribution system.

Fuzzy logic is a well-accepted Artificial Intelligence (AI) method designed to incorporate uncertainty with non-random characteristics of real world data. All the objects of the fuzzy system are categorized into fuzzy sets. The Fuzzy Logic processes use fuzzy sets to map the value of a fuzzy set member to a number between zero and one indicating its degree of membership, called fuzzy index [13].

The fuzzy index is the real data value describing outage handling procedure. The outage reports are grouped into three fuzzy sets according to their reliability indices: No Reports, Low Reliability Reports and High Reliability Reports.

The fuzzy index of the object is obtained by the fuzzy functions. Determination of the fuzzy member functions is the major task in the fuzzy logic, which transfers reliability reports into the fuzzy index. Fuzzy functions will be discussed in the next sections. The fuzziness of the object and used in the fuzzy engine for the fuzzy processing. The feature of fuzzy logic is the use of heuristics to compute the outputs. All the rules in the knowledge base are defined according to the relationship of the fuzzy sets, which allows the rules set to deal with uncertain input components.

B. Fuzzification:

Fuzzification procedure involves defining the fuzzy sets (rules) and describing the degree of membership in the fuzzy sets for each object i.e., determining the fuzzy index of each object.

In this project work, basically there are two possible information are from all the sources, namely "report outage" or "not report outage". The "report outage" can be further categorized according to the reliability index given to each reporting source in the data validation procedure. This reliability index is the major parameter used to decide the weight of every single outage report in the outage handling procedure. The outage reports are grouped into three fuzzy sets according to their reliability indices: No Reports, Low Reliability Reports and High Reliability Reports.

C. Fuzzy Rules:

As shown in table 2, four output fuzzy sets are defined as No Outage, Possibly No Outage, Possible Outage and Outage. The fuzzy rules are the most important component of the fuzzy system. They build the relations between input and output fuzzy sets. The complete and reasonable rules, which cover most of the possibilities and as many conditions, will assure the correctness of the fuzzy processing results.

The output of the de-fuzzification is the uncertainty that a specific customer location, as provided in the candidate list, experienced power loss. The reports with low uncertainty (uncertainty percentage is less than 50% will be put into the final outage information list. Other reports with high uncertainty will be discarded.

Table 2
Fuzzy rules for Information Filter

Number	AMR	TC	SCADA	Result
1	No	No	No	No Outage
2	No	No	Low	Probably No Outage
3	No	No	High	Probably Outage
4	No	Low	No	Probably No Outage
5	No	Low	Low	Probably No Outage
6	No	Low	High	Probably Outage
7	No	High	No	Probably Outage
8	No	High	Low	Probably Outage
9	No	High	High	Probably Outage
10	Low	No	No	Probably No Outage
11	Low	No	Low	Probably No Outage
12	Low	No	High	Probably Outage
13	Low	Low	No	Probably Outage
14	Low	Low	Low	Probably Outage
15	Low	Low	High	Outage
16	Low	High	No	Probably Outage
17	Low	High	Low	Probably Outage
18	Low	High	High	Outage
19	High	No	No	Probably Outage
20	High	No	Low	Probably Outage
21	High	No	High	Probably Outage
22	High	Low	No	Probably Outage
23	High	Low	Low	Probably Outage
24	High	Low	High	Probably Outage
25	High	High	No	Probably Outage
26	High	High	Low	Probably Outage
27	High	High	High	Outage

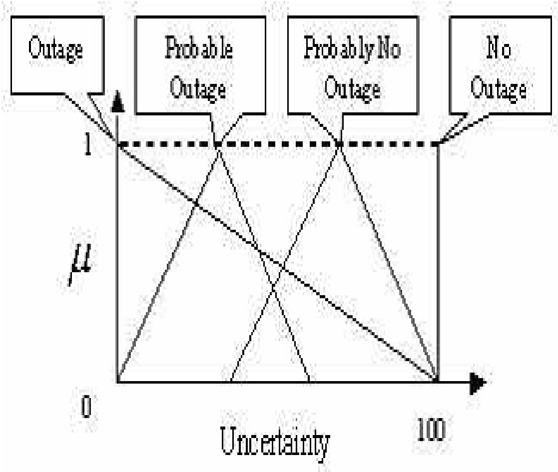


Figure14 Fuzzy rules with respect to Uncertainty and membership value

f. Restoration confirmation by Meter Polling Algorithm:

The primary locating procedure used the traditional outage escalation method to provide the outage region and the question points. Escalation is roughly defined as raising the level of a job from a downstream device to a device upstream [14]. This operation is based on the assumption that it is more likely for one device to fail than several. With this assumption, the outage escalation process searches the outage reports for common points of connectivity. The primary locating procedure provides the questioned devices that need to be checked.

g. ***. Restoration Confirmation by Meter Polling:***

1) On-Demand Read of AMR:

The AMR system is discussed in this project work, the meters do not communicate directly with the utility. Instead, they send the information to a microcell controller (MCC). The utility can communicate directly with the MCC by doing an on-demand read to retrieve information processed locally by the controller. This allows the utility to ask the MCC for the most recent information received from a meter. The data returned using the on-demand read has very high quality, approximately 95% [6]. The on-demand read process can be used to confirm the outage location before sending a crew to the scene to check the status of the customer. A polling scheme should be designed to allow the utility to learn as much information as possible about the status of the system with a limited number of on-demand reads.

An on-demand read is based on the following assumptions [5].

- The meter query process time is small and the time taken to execute a query and extract the read time is considered negligible.
- The packet success rate (PSR) is assumed to be constant and varies little between the time of the outage and the time the query is executed. PSR of the meter corresponds to the probability of the meter's ability to communicate successfully to the gateway device.

2) System Restoration Confirmation by Meter-Polling:

With the installation of automated meters, many utilities are beginning to see the possibilities for using an AMR system during outage situations, but have been unable to develop and implement a plan to effectively use the information available. Here, a meter-polling scheme will be introduced using on-demand read feature of the AMR system to confirm the outage restoration.

a) Status of the meter polled:

The meter status in the MCC is the status of the meter at its last report time. Theoretically if a meter was out, the meter should send *"Power out"* Flag to the MCC and then the MCC should send the outage notifications to the utility. In this algorithm we only poll a meter that the utility heard nothing from its associated MCC. If the polling result is *"out"*, then the meter must have encountered some technical problem so that either the status in the MCC is wrong or the MCC failed to report the outage. The following are the possible meter statuses based on the information from meters polled.

- "On": The meter sent a regular packet after the reported outage.
- "Probably on": The meter reported "power up" signal to a MCC, but the MCC failed to send the report to the utility.
- "Unknown":
  - MCC did not send outage notification, but no new packet was received from this meter after the reported outage, or
  - The meter sent the last gasp signal to a MCC, but the MCC failed to send this outage notification to the utility.

b) Ranking:

Before starting the meter polling, the meters under the checked device have to be ranked based on the links to the questioned point and the PSR of the meter. The meter with highest rank will be polled first. The ranking is based on two criteria:

- *Fewest links:*

  The fewest number of devices between the questioned point and the meter will be minimize the possibility that the middle device failure caused the meter outage.

- *Higher PSR:*

  The meter with the highest PSR can provide better quality data. If several meters have the same number of links, the meter with highest PSR should be polled first.

The ranking method described above provides a good coverage of the network and ensures better quality of the information received from the meters polled.

c) Meter Polling Scheme:

The purpose of meter polling is to confirm the outage status of the questioned device. The questioned device determined by the escalation method is the device that has more than one "power out" downstream devices. There are at least three possibilities that may cause this situation.

- The upstream device of the questioned device has a power outage, but no other devices under this device have reported an outage besides the questioned device.
- The outage is at the questioned device.
- There are multiple downstream device outages and no outage at the questioned device.

Figure15 shows the flow chart of the meter-polling algorithm. Basically if two meters were polled with an "unknown" status, the checked device would be considered to have an outage. If any one of the meters is polled with "ON," the checked device is "ON." The procedure also involves the meter ranking and re-ranking. If there is more than one questioned device, the procedure will start at the highest level.

By polling a limited number of meters, the algorithm can obtain the best description of the system status, and pinpoint the exact outage device(s). Moreover, the algorithm can also provide the additional checking suggestion based on the additional information available, such as weather conditions and the outage history of the vulnerable devices.

5.5 Flow Chart of the Restoration confirmation using Meter polling

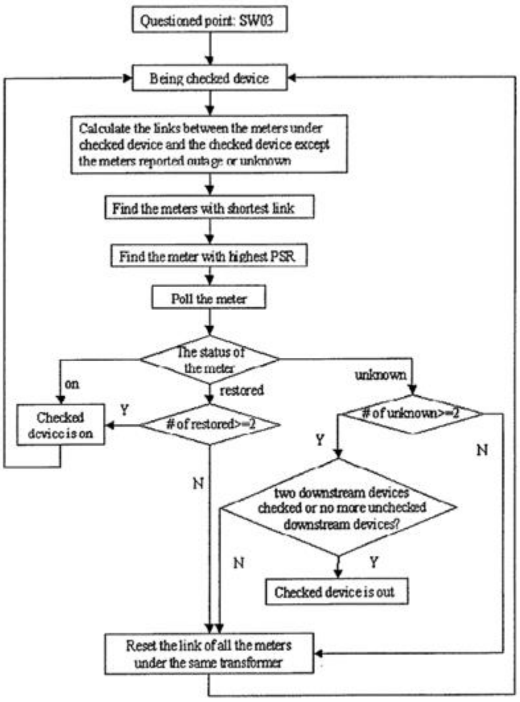


Figure 15 Restoration confirmation by Meter Polling

V. IMPLEMENTATION WORK OF PROPOSED ALGORITHM

1. EXAMPLE CASE REVIEW:

The meter polling algorithm was tested on Fig 16 example case feeder diagram. This feeder is a simple distribution feeder with 3 switches, 9 transformers with 28 customers. In the feeder diagram outage locations are marked ‘X’ in the feeder diagram. After, the network updated the status of system components according to outage notification. In this example feeder diagram, question mark indicates the question points. In the meter polling algorithm, the polled meters are indicated by ‘box’ in the feeder diagram.

By the system data obtained from the test system, run the load flow in ***“MATLAB 7.6 R2007 b”*** tool box. From the results of the load flow studies, the meters can receives the system status signals, which is for the power status of the system during normal, after fault and after fault cleared i.e., after restoration of the system. The below case is an example to describe the how the meter-polling is effectively runs for to find out the system status in the distribution network.

The meters under BK01 are polled first to confirm whether the system is “ON” or OFF”. If a fault occurs in XR09 was polled with status “ON”, this cleared out the possibility that BK01 had an outage. The meters under switch SW01 we polled. Two meters were polled with status of “UN KNOWN” status, so switch SW01 was assumed out. The meters under the switch SW03 was polled as “ON” status which means SW03 is also had an outage. So the final outage locations were pinpointed at switches SW01 and SW03.

Table 3 shows the results of meter-polling procedure results are pinpointed exact outage locations at switches SW01 and SW03.

Table 3
Meter Polling Algorithm results

Checked device	**Meter Polled and Polled Status**	
BK01	XR09	“ON”
SW01	XR01	“UN KNOWN”
	XR02	“UN KNOWN”
SW03	XR06	“UN KNOWN”
	XR07	“UN KNOWN”

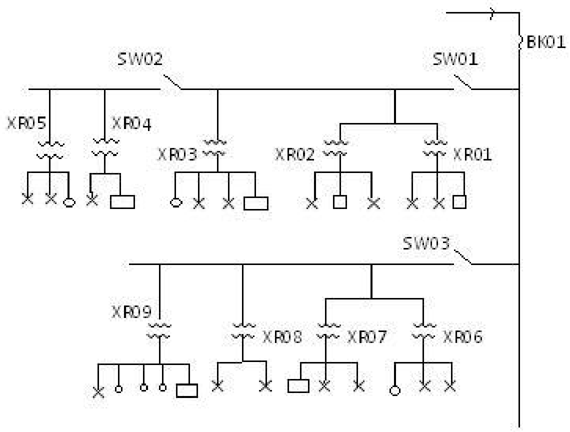


Figure 16 Example case Feeder Diagram

After the fault cleared, the system is restored then any meters under BK01 are polled (Example, meter id EC28), gives the power status “ON”. So then BK01 is cleared. Then the meters under SW01 and SW03 are polled. In switch SW01, meters under the transformers XR01 and XR02 and in switch SW03, the transformers XR06 and XR07 are polled. This gives the results of power status “ON”, it is cleared that the service is restored in the system.

2. Restoration Report Discussion:

In the table 3 result list, several meters shows report of power restoration action. The outage reports from these customers or from their meters are represents as the power restored, after the fault is cleared in the de-energized area or the fault areas.

A. TEST CASES AND SIMULATION RESULTS

The algorithm has been tested for the three test cases on 44 bus distribution network and the results have been tabulated for Bus number, Bus status, Transformer Id, Meter Id, PSR value and the Polled PSR. In this project work, the polling algorithm is done by using ***“MATLAB 7.6 R2007 b”*** for restoration confirmation of the system.

3. Parameter Selection:

In the proposed algorithm, the parameter selection of network is important for the restoration confirmation is as following:

- Check for the Bus number
- Checking the Bus status
- Transformer Ids
- Meter Ids under the every transformer and
- Meter PSR values.

3.1. . Check for the Bus number:

The entire network has 4 feeders having 44 buses. We will check the bus identification number and is belongs to which feeder. After identifying the bus identification number, proceeded, to its below levels to further checking needed for the problem evaluation.

3.2. Checking Bus Status:

The Bus status checking is very important parameter selection in the meter polling algorithm. The Automated Meters which are installed in every customer levels, which identifies the every status of the bus i.e., “Power On”, “Power Off and “Power Restored”, when it subjected normal, after fault and after restoration of the system.

3.3. . Transformer Id:

The Transformer Id is another parameter, which is connected in every bus in our problem network, having several customers (i.e., Automated Meters) in every individual transformer in the network.

3.4. . Meter Ids under Transformer and Meter PSR:

The Meter Ids and its PSR values are very much essential parameters in the meter polling algorithm. Using the PSR value in the meter polling algorithm, we rank the meters which are under the same transformer. The ranking of the meters shows, which one have to poll first under same transformer for the polling algorithm. When the meters under one transformer polled completely, then polling procedure is goes to the next transformer meters.

We analyze the simulation results of the meter polling algorithm of the AMR system using PSR value for the system status. If the PSR is high (i.e., nearly 100), the affection of stimulating result will be enhanced and the status obtained by using this PSR value will be good polling simulation result.

The test cases are evaluated in three test cases using the meter polling algorithm to check the status of the system. The test cases using in project work are as follows:

- Test Case 1 tested under Normal condition
- Test Case 2 tested after Fault in the system
- Test Case 3 tested after Restoration of the system.

4. Test Case1: Under Normal Condition

The developed meter polling algorithm has been applied to a 44-bus system under normal condition using ***“MATLAB 7.6 R2007 b”***, and the results are discussed below. It is four feeder distribution system of radial structure, having seven tie switches. In this test case all sectionizing switches should be close and all the tie switches should be open for the test. The 44-bus system of test case is shown in Figure 17.Input data for this system is given in Annexure A.

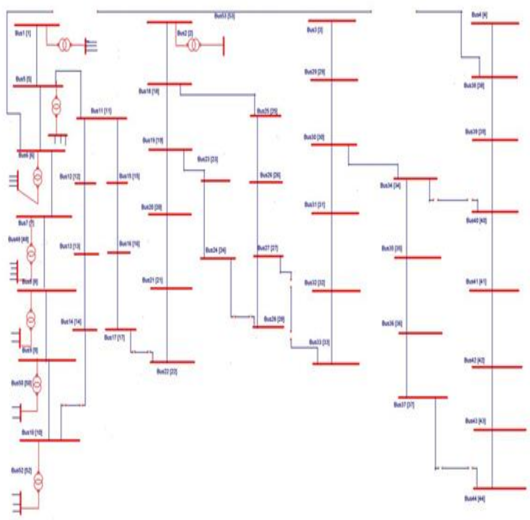


Figure 17 144-bus system of test case

Here, the every meter’s PSR values are polled, the one highest PSR value in that polled meters shows the status of the system during normal condition. Once all the meters which are under the same transformer is completed, then the polling algorithm is go to the next transformer meters for the further polling procedure. The network is shown aboves is under normal condition.

Meter Polling Simulation Results under Normal Condition

BUS NUMBER	BUS STATUS	TRANS_ID	METER_ID	PSR_VALUE	POLLED_PSR
1	"POWER ON"				
		T 11	1001	98	
		T 11	1002	99	
		T 11	1003	97	
					99
2	"POWER ON"				
		T 22	1004	92	
		T 22	1005	93	
		T 22	1006	95	
					95
3	"POWER ON"				
		T 33	1007	96	
		T 33	1008	97	
		T 33	1009	98	
		T 33	1010	95	
					98
4	"POWER ON"				
		T 44	1011	98	
		T 44	1012	99	
					99
5	"POWER ON"				
		T 15	1013	99	
		T 15	1014	99	
					99
6	"POWER ON"				
		T 16	1015	98	
		T 16	1016	93	
		T 16	1017	94	
					98
7	"POWER ON"				
		T 17	1018	98	
		T 17	1019	98	
		T 17	1020	98	
		T 17	1021	97	
					98
8	"POWER ON"				
		T 18	1022	93	
		T 18	1023	94	
					94
9	"POWER ON"				
		T 19	1024	95	
		T 19	1025	96	
					96
10	"POWER ON"				
		T 110	1026	97	
		T 110	1027	98	
		T 110	1028	99	
					99
11	"POWER ON"				
		T 111	1029	88	
		T 111	1030	89	
					89
12	"POWER ON"				
		T 112	1031	87	
		T 112	1032	86	
		T 112	1033	89	
		T 112	1034	90	
					90
13	"POWER ON"				
		T 113	1035	96	
		T 113	1036	97	
		T 113	1037	93	
		T 113	1038	94	
					97
14	"POWER ON"				
		T 114	1039	93	
		T 114	1040	92	
		T 114	1041	91	
					93
15	"POWER ON"				
		T 115	1042	99	
		T 115	1043	98	
		T 115	1044	96	
					99
16	"POWER ON"				
		T 116	1045	97	
		T 116	1046	98	
		T 116	1047	99	
		T 116	1048	99	
					99
17	"POWER ON"				
		T 117	1049	89	
		T 117	1050	90	
		T 117	1051	91	
		T 117	1052	92	
					92
18	"POWER ON"				
		T 218	1053	93	
		T 218	1054	94	
		T 218	1055	95	
					95

19	"POWER ON"				
		T 219	1056	95	
		T 219	1057	96	
		T 219	1058	98	
		T 219	1059	98	
					98
20	"POWER ON"				
		T 220	1060	99	
		T 220	1061	99	
					99
21	"POWER ON"				
		T 221	1062	99	
		T 221	1063	98	
		T 221	1064	97	
					99
22	"POWER ON"				
		T 222	1065	98	
		T 222	1066	97	
					98
23	"POWER ON"				
		T 223	1067	96	
		T 223	1068	95	
		T 223	1069	93	
					96
24	"POWER ON"				
		T 224	1070	94	
		T 224	1071	95	
					95
25	"POWER ON"				
		T 225	1072	96	
		T 225	1073	97	
		T 225	1074	98	
		T 225	1075	99	
		T 225	1076	93	
					99
26	"POWER ON"				
		T 226	1077	94	
		T 226	1078	93	
		T 226	1079	92	
					94
27	"POWER ON"				
		T 227	1080	93	
		T 227	1081	93	
					93
28	"POWER ON"				
		T 228	1082	93	
		T 228	1083	94	
		T 228	1084	95	
		T 228	1085	98	
					98
29	"POWER ON"				
		T 329	1086	94	
		T 329	1087	95	
		T 329	1088	97	
					97
30	"POWER ON"				
		T 330	1089	93	
		T 330	1090	94	
		T 330	1091	95	
					95
31	"POWER ON"				
		T 331	1092	96	
		T 331	1093	97	
					97
32	"POWER ON"				
		T 332	1094	98	
		T 332	1095	99	
		T 332	1096	96	
					99
33	"POWER ON"				
		T 333	1097	95	
		T 333	1098	96	
					96
34	"POWER ON"				
		T 334	1099	91	
		T 334	1100	92	
					92
35	"POWER ON"				
		T 335	1101	93	
		T 335	1102	94	
					94
36	"POWER ON"				
		T 336	1103	92	
		T 336	1104	93	
					94
37	"POWER ON"				
		T 337	1106	97	
		T 337	1107	98	
					98
38	"POWER ON"				
		T 438	1108	92	
		T 438	1109	93	
		T 438	1110	94	
					94

39	"POWER ON"				
		T 439	1111	91	
		T 439	1112	95	
		T 439	1113	96	
					96
40	"POWER ON"				
		T 440	1114	95	
		T 440	1115	96	
		T 440	1116	97	
		T 440	1117	98	
					98
41	"POWER ON"				
		T 441	1118	92	
		T 441	1119	93	
		T 441	1120	94	
		T 441	1121	95	
					95
42	"POWER ON"				
		T 442	1122	96	
		T 442	1123	97	
					97
43	"POWER ON"				
		T 443	1124	97	
		T 443	1125	98	
					98
44	"POWER ON"				
		T 444	1126	91	
		T 444	1127	90	
		T 444	1128	92	
		T 444	1129	93	
		T 444	1130	99	
					99

7.2.2 Graphs of Voltage Profile during Normal Condition:

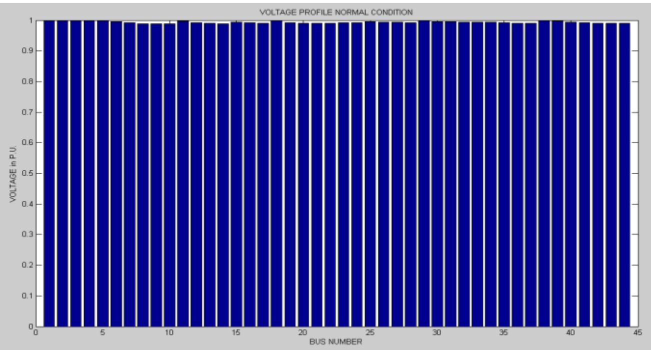


Figure18 Voltage Profile during Normal Condition in p.u

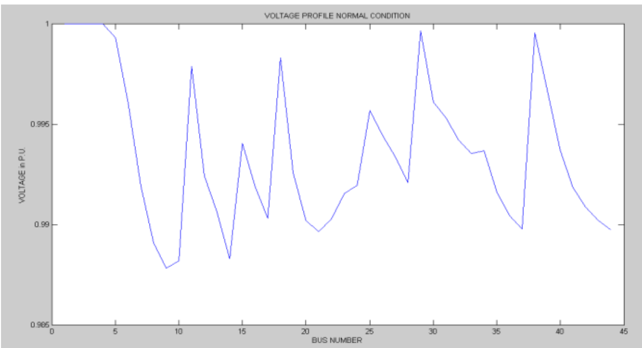


Figure19.Variation of Voltage Profile in p.u during Normal Condition with respect to buses

1. Test Case2: After Fault in the system:

The developed meter polling algorithm has been applied to a 44-bus system after fault occurred in the system and the results are discussed. The network is shown below is after the fault occurred. Input data for this system is given in Annexure B.

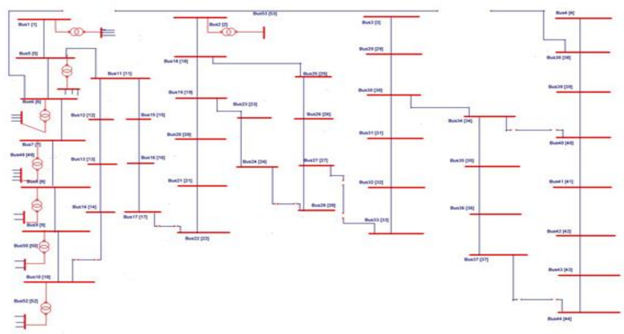


Figure19 44-bus system of test case

The fault is introduced in between the busses 6 and 7 and second fault is introduced in between the 30 and 34. Then the power is nearly zero in7, 8, 9, and 10 in first de-energized area and 34, 35, 36 and 37 buses in the second de-energized area. In this situation all the tie switches are open and the sectionizing switches in the faulted line are opened. When the polling procedure is implemented for the network, poll the every meter's PSR values.

In this test case, the polling procedure choose only two highest PSR values in that polled meters, shows the status of the system after the fault occurred. Once all the meters which are under the same transformer is completed, then the polling algorithm is go to the next transformer meters for the further polling procedure.

1.1. Results of Test Case 2:

Meter Polling Simulation Results for After Fault Occurred

BUS NUMBER	BUS STATUS	TRANS_ID	METER_ID	PSR_VALUE	POLLED PSR
1	"POWER ON"				
		T 11	1001	98	
		T 11	1002	99	
		T 11	1003	97	
					99
					98
2	"POWER ON"				
		T 22	1004	92	
		T 22	1005	93	
		T 22	1006	95	
					95
					93
3	"POWER ON"				
		T 33	1007	96	
		T 33	1008	97	
		T 33	1009	98	
		T 33	1010	95	
					98
					97
4	"POWER ON"				
		T 44	1011	98	
		T 44	1012	99	
					99
					98
5	"POWER ON"				
		T 15	1013	99	
		T 15	1014	99	
					99
					99
6	"POWER ON"				
		T 16	1015	98	
		T 16	1016	93	
		T 16	1017	94	
					98
					94
7	"POWER OFF"				
		T 17	1018	98	
		T 17	1019	98	
		T 17	1020	98	
		T 17	1021	97	
					98
					98
8	"POWER OFF"				
		T 18	1022	93	
		T 18	1023	94	
					94
					93
9	"POWER OFF"				
		T 19	1024	95	
		T 19	1025	96	
					96
					95
10	"POWER OFF"				
		T 110	1026	97	
		T 110	1027	98	
		T 110	1028	99	
					99
					98
11	"POWER ON"				
		T 111	1029	88	
		T 111	1030	89	
					89
					88
12	"POWER ON"				
		T 112	1031	87	
		T 112	1032	86	
		T 112	1033	89	
		T 112	1034	90	
					90
					89
13	"POWER ON"				
		T 113	1035	96	
		T 113	1036	97	
		T 113	1037	93	
		T 113	1038	94	
					97
					96
14	"POWER ON"				
		T 114	1039	93	
		T 114	1040	92	
		T 114	1041	91	
					93
					92
15	"POWER ON"				
		T 115	1042	99	
		T 115	1043	98	
		T 115	1044	96	
					99
					98
16	"POWER ON"				
		T 116	1045	97	
		T 116	1046	98	
		T 116	1047	99	
		T 116	1048	99	
					99
					99
17	"POWER ON"				
		T 117	1049	89	

		T 117	1050	90
		T 117	1051	91
		T 117	1052	92
				92
				91
18	"POWER ON"			
		T 218	1053	93
		T 218	1054	94
		T 218	1055	95
				95
				94
19	"POWER ON"			
		T 219	1056	95
		T 219	1057	96
		T 219	1058	98
		T 219	1059	98
				98
				98
20	"POWER ON"			
		T 220	1060	99
		T 220	1061	99
				99
				99
21	"POWER ON"			
		T 221	1062	99
		T 221	1063	98
		T 221	1064	97
				99
				98
22	"POWER ON"			
		T 222	1065	98
		T 222	1066	97
				98
				97
23	"POWER ON"			
		T 223	1067	96
		T 223	1068	95
		T 223	1069	93
				96
				95
24	"POWER ON"			
		T 224	1070	94
		T 224	1071	95
				95
				94
25	"POWER ON"			
		T 225	1072	96
		T 225	1073	97
		T 225	1074	98
		T 225	1075	99
		T 225	1076	93
				99
				98
26	"POWER ON"			
		T 226	1077	94
		T 226	1078	93
		T 226	1079	92
				94
				93
27	"POWER ON"			
		T 227	1080	93
		T 227	1081	93
				93
				93
28	"POWER ON"			
		T 228	1082	93
		T 228	1083	94
		T 228	1084	95
		T 228	1085	98
				98
				93
29	"POWER ON"			
		T 329	1086	94
		T 329	1087	95
		T 329	1088	97
				97
				93
30	"POWER ON"			
		T 330	1089	93
		T 330	1090	94
		T 330	1091	95
				95
				94
31	"POWER ON"			
		T 331	1092	96
		T 331	1093	97
				97
				96
32	"POWER ON"			
		T 332	1094	98
		T 332	1095	99
		T 332	1096	96
				99
				98
33	"POWER ON"			
		T 333	1097	95
		T 333	1098	96
				96
				95
34	"POWER OFF"			
		T 334	1099	91
		T 334	1100	92
				92
				91
35	"POWER OFF"			
		T 335	1101	93
		T 335	1102	94
				94
				93
36	"POWER OFF"			
		T 336	1103	92

		T 336	1104	93	
		T 336	1105	94	
					94
					93
37	"POWER OFF"				
		T 337	1106	97	
		T 337	1107	98	
					98
					97
38	"POWER ON"				
		T 438	1108	92	
		T 438	1109	93	
		T 438	1110	94	
					94
					93
39	"POWER ON"				
		T 439	1111	91	
		T 439	1112	95	
		T 439	1113	96	
					96
					95
40	"POWER ON"				
		T 440	1114	95	
		T 440	1115	96	
		T 440	1116	97	
		T 440	1117	98	
					98
					97
41	"POWER ON"				
		T 441	1118	92	
		T 441	1119	93	
		T 441	1120	94	
		T 441	1121	95	
					95
					94
42	"POWER ON"				
		T 442	1122	96	
		T 442	1123	97	
					97
					96
43	"POWER ON"				
		T 443	1124	97	
		T 443	1125	98	
					98
					97
44	"POWER ON"				
		T 444	1126	91	
		T 444	1127	90	
		T 444	1128	92	
		T 444	1129	93	
		T 444	1130	99	
					99
					93

VI. CONCLUSION

The primary distribution feeders are generally operated in a radial fashion. A fault clearing by the protection devices causes an outage, which should be restored by utilizing the neighboring backup feeders as quickly as possible. Before the distribution automation was introduced, the section loading measurements were not available to the operators, so a feeder was generally loaded around 50% of its maximum capacity assuming it would take over the whole load of the neighboring feeder in case of the fault. This operating philosophy has resulted in very low efficiency and low utilization of power facilities. With real-time monitoring and remote control of the distribution system available in the distribution automation system (DAS), efficiency, and economy in system operation and facility management can be obtained. Recently, this is being reemphasized due to the deregulation issue that is pushing the economic factor on the top concern.

To secure the service continuity is the most important job in the distribution system operation. So the service restoration for the outage area is considered as the most important function in the distribution automation. Service restoration problem has a combinatorial nature since it deals with the on/off status of the switches.

This project work describes the fast restoration procedure and the meter polling procedure is to confirm the system restoration. The purpose of this procedure was to find an efficient method use the comprehensive outage notifications, provide fast and effective way to locating outages and restoration processes. A knowledge-based system was developed to provide an integrated approach for solving the problems which integrated in the outage locating procedure in the system [6]. It creates the list of possible outage locations and addition weather suggestions.

The major contribution of this work using these procedures by AMR systems are i) using the comprehensive outage information from trouble calls, SCADA and AMR systems for exact outage locations and ii) design and developed meter-polling procedure for confirmation of outage locations and system restoration iii) helped the utilities gain access to consumer consumption data, power quality in the system and real-time outage notifications.

The restoration process in the distribution system of the most outages can confirm without polling every meter in affected area using its PSR value of the meters. We taking an account of the PSR value on the high quality of data returned for different status in the system could be find out after a thorough search by running this meter-polling procedure using on-demand read test case comprehensive information [5]. The on-demand read of the AMR system provide utilities that can be indirectly communicating with the customers. With further development and testing of the system using the polling procedure with intelligent outage handling system [6] can be integrated in the every distribution system operation for locating outages and restoration confirmation processes. This will improve the quality of the outage handling process, reduces the errors in the outage locating and reduces the cost during outages.

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