Application of Multi Agent System

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ABSTRACT

This paper deals with the application of a multi agent system (MAS) for service restoration in distributed power systems. In this paper, the part of the service restoration process which deals with restoring power to consumers in case of an outage, is considered. A restoration strategy based on agent technology has been formulated. This strategy proposes a method for prioritizing certain consumers as part of the restoration process. A multi agent system has been developed in JADE, a software framework specifically suited for the development of agent software systems. A simple distribution network has been used as the basis for simulating the operation of the MAS. In order to verify the capability of the MAS software, it has been tested with two kinds of fault scenarios occurring in the distribution network., it has been considered how to connect a MAS developed in JADE with a model of a physical network. The intention for this has been the potential for simulating the interaction between the MAS in JADE and a realistic physical model of a distribution network. Matlab Simulink has been used to build a model of a physical network and a communication between Matlab and JADE has been established. The MAS has been seen to perform successfully to different fault scenarios. The results of this paper have been a demonstration of a multi agent system as an approach to power service restoration. Thus, it has been demonstrated how FIPA protocols and ontologies can be utilized in a multi agent system to add intelligence to the service restoration process.

Keywords

Load Restoration, Multi-Agent System (MAS), Decentralized solution.

1. INTRODUCTION

When a fault occurs in a microgrid system, corresponding circuit breakers will be opened to isolate the fault so as to protect the power equipment. During the process, some unfaulted loads are forced to be out of service. Restoring power supply to these deenergized but unfaulted loads as soon as possible is of great importance [1]. Service restoration is the process of detecting the fault, isolating the fault and restoring the power to those consumers which have experienced an outage. This paper deals with the part of the process which concerns the restoration of power to the consumers. This is achieved by closing or opening a number of switches in the network, so power can be rerouted or provided by alternative sources if necessary. This reconfiguration of the network is subject to several constraints. Thus Efficient restoration methods are very important for energy utilization and service quality. In the past years, various soft computing algorithms have been applied to solve the load restoration problem, such as genetic algorithm [3], particle swarm optimization [4], artificial neural networks [5], and tabu search [6]. These methods require a powerful central controller to handle huge amount of data and transmission of global information among networks. These centralized schemes are costly and easy to suffer from single-point failures. Furthermore, the centralized control scheme lacks adaptively to structure changes of power networks. When new generators and loads are installed, centralized control scheme may need to be redesigned. Considering the uncertainty of intermittent renewable energy resources, generation fluctuation may result in unintentional structure changes, which will further increase the burden to centralized schemes. Since distributed control scheme can overcome the above mentioned shortcomings, distributed control scheme looks like a better solution for the reliable and low-cost load restoration

2. DISTRIBUTION SYSTEM RESTORATION

Modern power systems are in general considered to be highly reliable. However, with the restructuring of the electric power industry towards a market based business environment, pressure to reduce costs has increased, and as a result power systems are operated closer and closer to their limits [6]. This development has led to an increasing number of blackouts [10]. In case of an outage the utility companies perform service restoration.

Restoration may require the investigation of massive combinations of switching operations that satisfy multiple objectives under certain constraints [2].

1. Transmission lines in a distributed system can only

transmit a limited amount of power. It might not be possible to recover some loads in the outage area due to such line constraints.

2. There is a constraint on the amount of power which

can be provided by alternative sources. If too many loads are restored, the system might get overloaded resulting in a shift in the power balance of the network and a frequency decrease, which is undesirable.

3. Distribution systems are typically radially structured.

During reconfiguration it is usually important to maintain this network structure as much as possible to keep the network configuration as simple as possible. Interconnecting different subsystems will create loops, and make the configuration more complicated. In addition to dealing with the objective of restoring as many loads as possible during an outage, this paper will also consider a prioritization of the individual loads. The causes of an outage could be many: Transient faults propagating through the network, the loss of a power source due to a generator fault, or faulty equipment e.g. the loss of a transmission line. Transient faults mainly occur in transmission systems, and most of these faults are cleared by protective systems [9]. Still, some faults turn out to cause a permanent partial or complete blackout of distribution areas. The primary objective of service restoration is to restore as many possible until the fault is cleared. This is achieved by closing or opening a number of switches in the network, so power can be rerouted or provided by alternative sources if necessary. This reconfiguration of the network is subject to several constraints.

3.MULTI AGENT SYSTEM

The multi agent system (MAS) is one of the most popular distributed control solutions. Advantages of MAS include the ability to survive single-point-failures and decentralized data processing, which leads to efficient task distribution eventually causing faster operation and decision-making process [7]. In artificial intelligence, agent-based technology has been hailed as a promising paradigm for conceptualizing, designing, and implementing software systems.

Recently, MAS have been widely applied to the restoration of distributed networks, such as [8] –[10]. It can solve the load restoration problem in a distributed way.

4.NETWORK CASE STUDY

In the system, power is provided from two sources, Source1 and Source2, each through a distributed transformer. Each transformer provides power to three feeders A, B and C, where each feeder includes four buses each having a load attached. Switches are symbolized with a square symbol in the diagram; here a black filling denotes that the switch is close while a white filling symbols an open switch.

All feeders are connected with each other making it possible to reconfigure the network in numerous ways. Each feeder is connected with the other feeders fed from the same source through the switches denoted SAB, SBC and SAC. In addition, all feeders are connected with feeders from the other source through the tie switches T1 –T9. On each feeder every bus is separated by a switch, making it possible to isolate one or more buses of the feeder if necessary. In normal operating conditions of the network all these sectionalizing switches are closed, as shown in the figure.

Transmission lines impose constraints on how much power can be transmitted. For the sake of simplicity each feeder has been assigned a maximum allowable MW is flowing through it. This will limit the amount of load which can be connected to the feeder in addition to its own loads. How much a feeder can provide to another feeder then de- pends on its current load consumption. A power flow capacity of 500 MW will be used for all feeders in the subsequent simulations. It is desirable to keep a radial structure in the network during restoration. This structure can be enforced whenever possible by assigning distances between the six feeders. The feeder 1A can be connected with one of the feeders 1B, 1C and 2A. Feeder 1A should be connected to the feeder closest to 1A is feeder 1B, with the distance 1. The feeder least desirable for feeder 1A to interconnect to feeder 2C with a distance of 5.

5. SYSTEM ARCHITECTURE

The multi agent system architecture and the division of responsibilities between the individual agents, has been built.

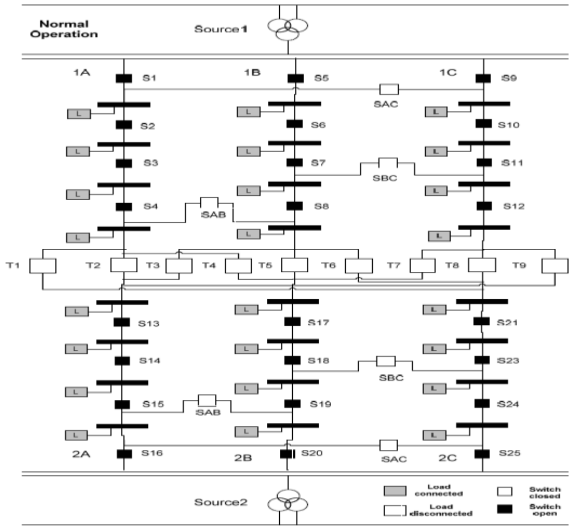

Fig.1 Network diagram with location of agents

The Bus Agent represents a particular bus and is responsible for monitoring one or more loads attached to this bus. It can control two switches on either side of it in order to isolate the bus if necessary, see figure 5-1. The Bus Agent reports to the Feeder Agent in the case of any abnormal system changes, that is if power is not supplied to its load or if power has been restored. It also receives orders from the Feeder Agent to connect or disconnect its switches or load.

The Feeder Agent represents a feeder and is responsible for initiating power negotiations with others feeders on behalf of its Bus Agents in case of a power outage. If the Feeder Agent has succeeded in providing power to its Bus Agents from another feeder, it sends a command to the appropriate Bus Agent to connect the two feeders.

Bus Agents monitor a number of measurement devices. These include power flow measurement devices situated at the loads, which continuously measures the power consumed by the loads. Abnormal system changes in the network, like the loss of voltage, would be detected by these measurement devices. The Bus Agent will then notify its Feeder Agent about these changes. If power to the load is lost, it will notify the Feeder Agent about this event along with the pre-fault power consumption of its load. The Feeder Agent will then decide on an action to take based on the information passed from several Bus Agents. These control actions are then passed down to the appropriate Bus Agents, which will perform the requested action, by controlling its switching devices.

6.RESTORATION STRATEGY

6.1 The Finite State Machine Behavior

The FSM behavior of the Feeder Agent is shown in the flowchart in fig. 2. Describes the behavior in a more detailed manner. The following gives a description of the conditions which leads the Feeder Agent through the different states.

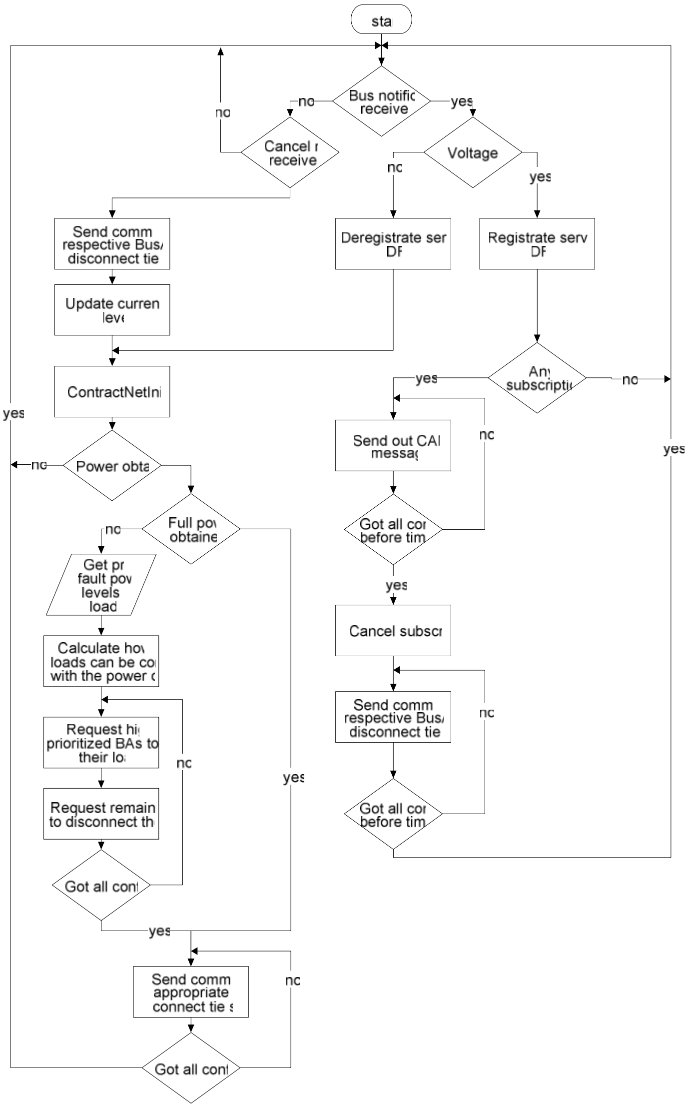

Fig.2. Flowchart of FSM behavior

State 1: The Feeder Agent (FA) starts in an idle state, state 1, waiting for notification messages from any of its Bus Agents (BAs). If a message is received, the information sent by the Bus Agent is evaluated. If power any power loss at the load is reported, the FA will store the pre-fault power value. In case several loads are left without power, the FA will add these individual pre-fault consumption values and go to the next state, state2, the FA receives notifications from its BAs that power has returned it will stay in the same state, state1, but register its services on the DF yellow pages since power has returned. Besides if the FA have done any subscriptions with other FA's during the outage period it will cancel these and send requests to the appropriate BAs to disconnect the interconnecting switches to these feeders. In this state, the FA are also waiting for any subscription cancellations from other FA’s

State2: In state 2 the behavior Contract Net Initiator () is invoked. When the Contract NetBehavior has been invoked, the Feeder Agent will move on to state 3.

State3: In state 3 the outcome of running the Contract Net Initiator behavior is evaluated. If no power has been obtained, the FA will return to the idle state, state 1. If the required amount of power has been fully obtained, it will go to state 5. If it has only been possible to restore part of the required power, the FA will attempt to prioritize its loads by going to state 4.

State 4: Based on the amount of power which has been obtained, the FA will decide on how many of the loads it is possible to restore. It will request each BA to either connect or disconnect its load. When all BAs have informed the FA that the action has been performed, it will go to state 5.

State 5: In this state, the FA will decide on which switch should be connected to get the power from the contractor. This could be a tie switch or a switch. Depending on from which other FA(s) the power is to be provided, the FA will request one of its BAs closest to the switch to connect it. When the BAs have informed that the actions have been performed successfully the reconfiguration is now complete and therefore the FA will return to the idle state, state .1

6.2 Fault scenario

The fault scenario to be considered is a line fault on the feeder. In this scenario the occurrence of two faults in the network is considered. First the loss of source 1 occurs. After this fault a line fault at feeder 2C occurs.

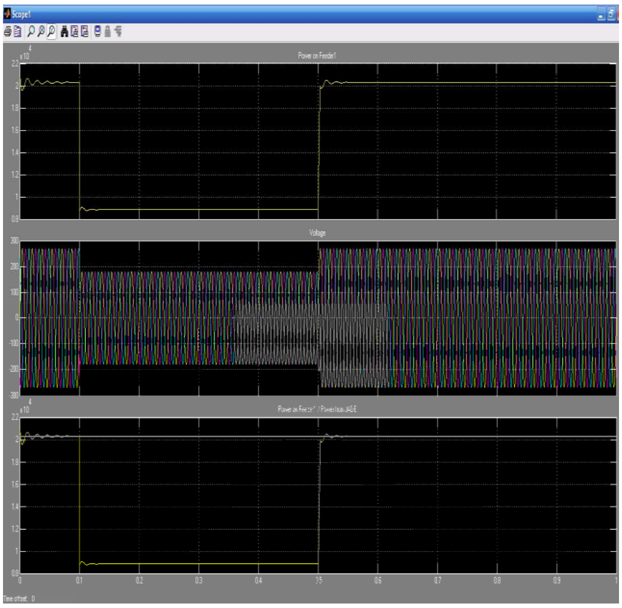

Fig.3. Result of simulated model with fault

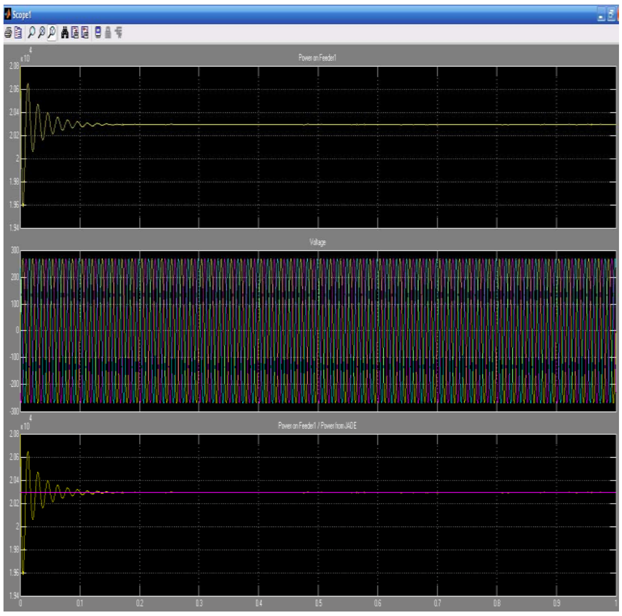

Fig.4. Result of the power restoration on the simulated model.

7. SIMULATION MODEL

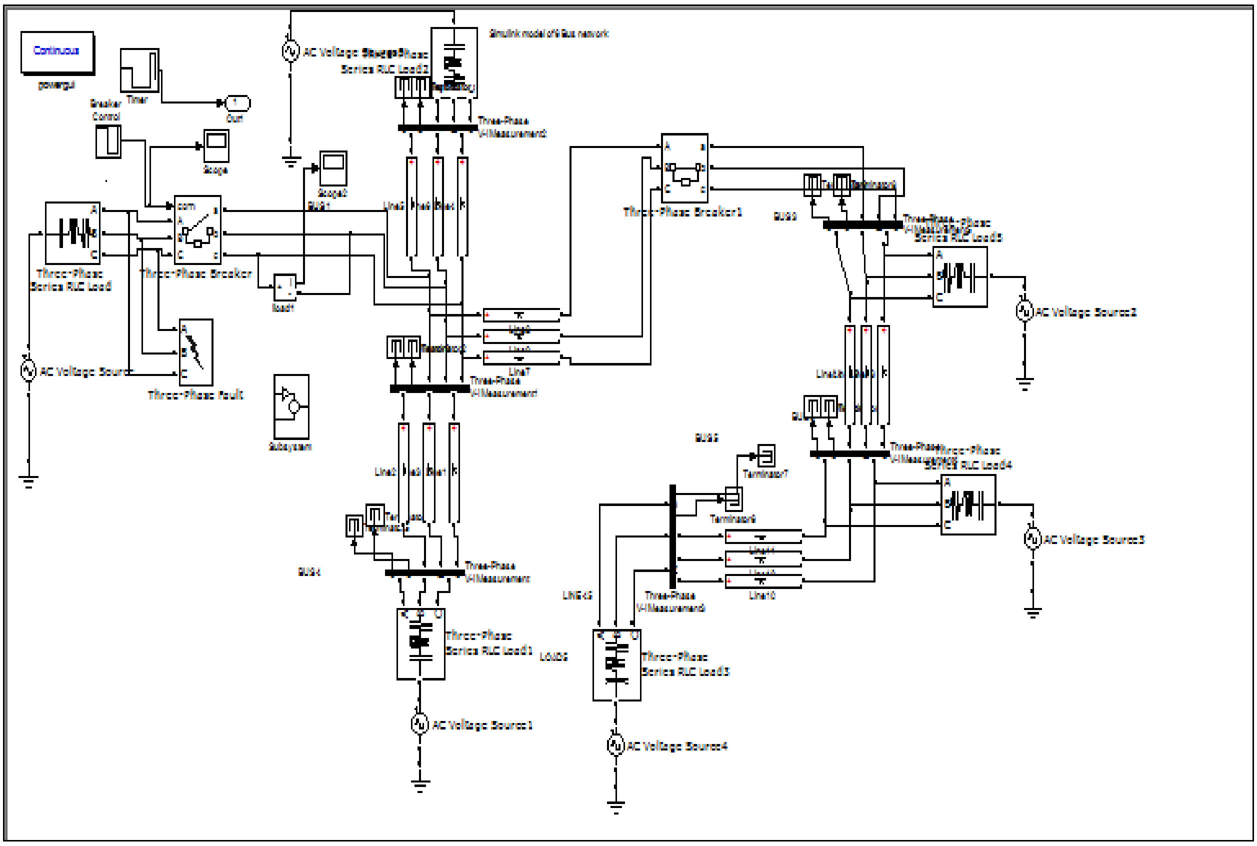

Fig.5. Simulation model for restoration

8. CONCLUSION

In this report an approach for applying agent technology to service restoration of a distribution network has been presented. A restoration strategy for prioritizing certain loads in case of shortage of alternative sources has been proposed. A multi agent system has been built using the JADE framework, to verify the restoration strategy. Two fault scenarios have been considered to verify the capability of the MAS. The test results demonstrate the Flexibility of the MAS, in terms of dealing with different types of network faults occurring one at a time or simultaneously. Furthermore, the potential for simulating a multi agent system behavior linked to a physical model in Matlab Simulink has been investigated. A connection between an agent system in JADE and a Matlab Simulink model has been setup, which allows measurement data to be transferred from Simulink and control commands to be sent from JADE to Matlab.

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