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Jade Implementation of Power Restoration in Automated Distributed System

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Abstract

Massive interconnection of power network has faced more operational difficulties. The multi agent based intelligent system has used to reduce the complexity, automated power distributions in power system. In this research work Jade implementation technique has used to isolate the fault line and has restored the nearest generator. The system model has developed in MATLAB and tested in JADE. It provides quick restoration without power loss will lead the power consumption in distributed automation power system.

Keywords: Automated Distribution System, Fault Isolation and JADE Tool, Multi Agent System, Power Restoration

1. Introduction

Distributed generator is small power supply unit which supplies to local load and can be directly connected to distribution network. It includes distributed power devices and distributed energy storage devices. Sophisticated, digitally enhanced power system with the use of modern communications[1] and control technologies which provides more robustness, efficiency and flexibility comes under the smart agent system. A Multi Agent System (MAS) is a combination of several agents working in collaboration pursuing assigned tasks to achieve the overall goal of the system[2,3]. This MAS technology provides a solution for creating such distributed control systems with secure and reliable network operations. Multiagent system offer their inherent benefits of flexibility, extensibility, autonomy, reduced maintenance and more[4]. The design and implementation of multiagent systems using JADE for smart grid system has discussed in this paper. The MAS is also known as intelligent system by soft computing[5,6] each agent like Neural Network, Fuzzy Logic, Genetic Algorithm and swarm optimization[7].

Electric Power Distribution Systems (EPDS) can be found almost everywhere, from ship power systems to data centers. In many critical applications, there is need to maintain minimal operating capability under fault conditions[8-11]. Therefore, it is necessary to develop energy distribution control techniques. To achieve this goal it is necessary to make a series of decisions and control actions.

- Detect the fault.
- Identify the fault resource and estimate its magnitude. (partial degradation vs. total failure)
- Take action depends on the nature of the failure which is to compensate it.

To achieve the distributed intelligence in the EPDS, some software techniques must be used. The software environment based agents are called as Agent Platform. The aspects related with agent technology and MAS[12] are standardized by The Foundation for Intelligent Physical Agents (FIPA)[13]. The load agent receives all the information about the power system and the feeder agent controls of the entire restoration process in accordance the restoration strategy. Liu et al., had proposed a centralized multiagent system to structure the power distribution between substations and end users[14]. Nordman ans Lehtonen presented their agent concepts for managing electrical distribution networks by using decentralized functionality. The distribution

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automation applications are executed by local substation controllers through collaboration with neighboring substations[15]. Solanki et al. presented a distribution restoration system with decentralized solution. Agents have the abilities to communicate and collaborate with other agents to perform individual or group tasks[16].

The main goal of fault detection, fault isolation is to effectively detect faults and accurately isolate them to a failed component and restore the remaining power quickly without any power loss. A system fault can be detected manually or automatically, depending on operating modes and how quickly the system needs to be restored. The implementation of multiagent system has been given in section II. Section III describes the implementation of load distribution and followed that restoration strategy has discussed in section IV. Simulation results are discussed in section V and conclusion in section VI.

2. Implementation of Multiagent System

The multi agent system is an integrated advanced sensing technology, control methods and integrated communications into current electricity grid for both in transmission level and distribution levels. The smart grid system has intelligent techniques for self healing, friendly consumer service, and attack resistant, provides power quality, optimizes assets and operates efficiently[17].

MAS are composed of multiple interacting software elements, known as agents and its proposed model has shown in Figure 1. JADE is a software framework fully developed in Java language, which facilitates implementation of MAS through a middleware. It is developed accordance with FIPA standards. It also has graphical tools which assist in development stages and to visualize the agent communication. It allows the agent platforms to be distributed among several power lines. The JADE (Java Agent Development Environment) was employed to implement the proposed agent based distribution system.

In result, Fault detection was simulated in JADE and reconfiguration was tested in MATLAB. The general model for the application of MAS for power distributed system. It has the load agents, switch agents and bus agents of these agents coordinate with each other in order to detect the faults in the system and re-route the power flow to better serve the customers[18,19]. In order to efficiently manage and control the power network, multi agent system have been employed to solve the challenges in power network and are being developed for a range of applications including fault diagnostics, system monitoring, system restoration, system simulation and system control. Nagata et al. has proposed a multi agent approach for decentralized power system restoration in the distribution system network[20].

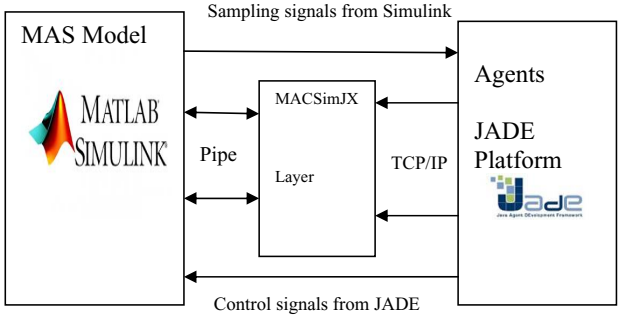

Figure 1. Proposed Multi Agent System.

3. Load Distribution Analysis in IEEE Bus

An algorithmic approach has been simulated using node agents, which are equals to the number of buses in the design. The modules of a node agent and the load restoration operation using multi agent system are illustrated in Figure 2. The original data of the each bus system are listed in Table 1. which have the P_{Gi} is the local generation, P_{Li} is the local load, X_i^o is the local net power are as per 7 bus agent system. If any sudden fault occurs to the generator on the particular bus, the protection system implies quick response to isolate the fault by opening the remaining switches. The post fault system after protection action and load are shared by the nearest generation.

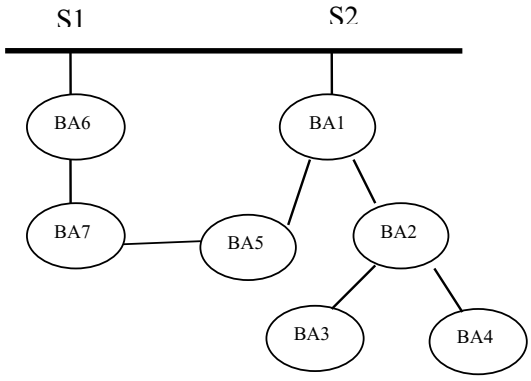

Figure 2. The 7 bus Agent system.

Table 1. Data of IEEE 7-Bus system

No	Neighbors	P_{Gi}	P_{Li}	X_i^o
1	2,5	200	0	200
2	1,3,4	0	120	–120
3	2	40	0	40
4	2	0	80	–80
5	1,6,7	0	60	–60
6	5,7	120	0	0
7	5,6	0	100	–100

4. Restoration Strategy in MAS

The FSM (Finite State Machine) behavior of the Feeder Agent is the flowchart shown in Figure 3. with five states

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, state 2, the FA receives notifications from its BAs that power has returned it will stay in the same state, state 1, but registers its services on the DF yellow pages since power have 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 is also waiting for any subscription cancellations from other FA's.

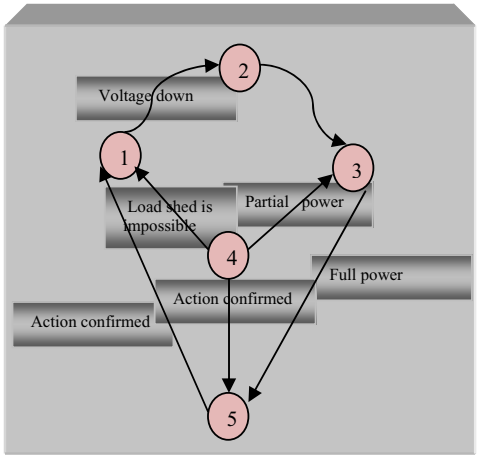

Figure 3. FSM of fault restoration.

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

State 3: 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.

5. Results and Discussion

The test system is simulated using Matlab Simulink in Sim Power Systems toolbox, and the MAS were implemented using Java programming language and JADE platform. A distribution network carries electricity for transmission network to customers through facilities such as substations, buses and feeders. Automatic distributed system is the new alternative for power resources to quick fault detection and isolation.

The speed of the investigation of the information for discovery process is very important for reloading the power. Since the load restoration is required only when the generation of power become more enough for available source and check the total net power immediately. The total net power can be obtained by adding up the all elements in third column which should not nonzero in the first column. The average total net power in MAS is shown in Figure 4 if the average total net power has positive value, then restored part or all of the unfaulted can be possible. Identify the restore parameters as soon as

possible to initiate the restoration process. The Figure 5. and Figure 6. are shows the result in fault and after restoration.

The JADE implementation shown in Figure 7. used to create the agents and request, query and inform are shared among the agents to recover the fault and immediate load distribution without any delay. 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.

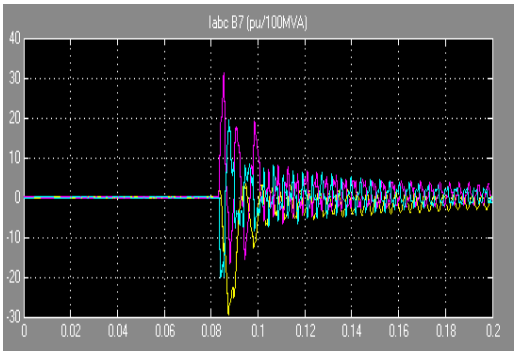

Figure 4. Avg net power discovery in 7 bus system.

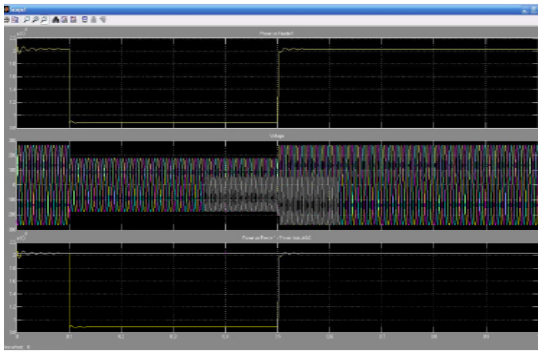

Figure 5. Result of fault occurrence.

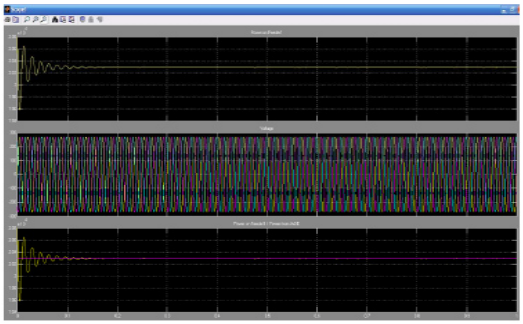

Figure 6. Result of the power restoration after the fault.

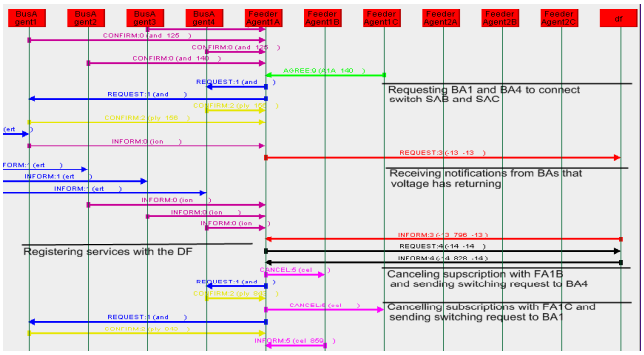

Figure 7. JADE Implementation.

6. Conclusion

In this work, an intelligent agent based MAS have designed for automatic distribution system. The designed 7 bus system of total net power 360 watts are properly stored and recovered when fault has occurred. In this work, an approach for applying agent technology to service restoration of a distribution network has been presented. Two fault scenarios have been considered to verify the capability of the MAS. 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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