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Multi-Objective Service Restoration for Blackout of Distribution System with Distributed Generators based on Multi-agent GA

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Abstract

Service restoration is a problem with multiple objectives and constraints, when the distribution systems with DGs (distributed generators) come up large area blackout. In this article the model of multiple objective service restoration about distribution systems with DGs has been built, considering users' priority, the action times of hand switches or tele-switches and network losses after service restoring. Multi-agent GA can be used to search the Pareto optimal solution set for the multiple objectives service restoration problem. Agent's competitive and selflearning actions reflect the principal of survival of the fittest and diversity. It can reduce complex rate and improve efficiency using challenge match method to form Pareto solution to store populations. At last the calculation example manifests the quickness and precision of the multiple objective service restoration for blackout based multi-agent GA, and it is better suit for the distribution system than single objective method.

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Keywords: Distribution network, Service restoration, Multi-agent GA, Distributed generation, Best Pareto solution

1. Introduction

With the power demand constantly increasing, the complex rate and scale of the modern power system has been greatly increasing. So the blackout probability and area also expand in the distribution system. In order to satisfy users' demand and maintain profit of power supply company, it is necessary to restoring power service as soon as possible [1]. Distribution system is designed in close loop and operated in open loop. So there are sectional switches on distribution lines and interconnecting switches in feeder inlets. Service restoration of distribution system is to operate a set of switches to restore power service [2].

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But there are some questions to be noticed in the process of service restoration:

- (1) Try best to restore service.
- (2) The time of running program is as short as possible.
- (3) Satisfy the constraints of distribution system.
- (4) The least times of switches are operated.
- (5) Consider priority of loads.
- (6) The network losses are as small as possible after service restoring.

Now DG technology has rapidly expand on the world. Based on the transmission system support, it can bring in DGs in the distribution system near users side. Users can get reliable power with using existing resources and devices. Inserting DGs can not change the structure of distribution system, and delay the large investment for upgrade lines. Meanwhile, it can effective improve reliability of transmission system and increase quality of supply. After the distribution system with DGs faulting, DGs can keep on supplying power in the manner of isolated island of electricity [3-7].

To solve distribution system service restoration problem, there are a lot of methods, for example, simulated annealing algorithm (SA), genetic algorithm (GA), tabu search algorithm and so on[8]. But most of methods are in the form of single objective or multiple objective weighting to single objective. Single objective can not wholly reflect real demand of distribution system service restoration, and weighting method is more dependent on personal experience. It must be as soon as possible for service restoration, but the speed algorithm for multiple objective is not enough quick. In this article Multi-agent GA for multiple objective service restoration has proposed, considered matters in service restoration. Multi-agent GA can be used to search the best Pareto solution set for the multiple objectives service restoration problem, considering users' priority, the action times of hand switches or tele-switches and network losses after service restoring. Agent's competitive and self-learning actions reflect the principal of survival of the fittest and diversity. It can reduce complex rate and improve efficiency using challenge match method to form Pareto solution to store populations. The purpose of the multiple objective service restoration is try to search as many solutions as possible in the quick speed, and offer a solution as service restoration case according real condition for decision maker.

2. Mathematical model for large-scale blackout restoration in distribution system with DGs

2.1. Simplification for distribution system topology structure

Distribution system net can be treated as a kind of figure. Feeder switches are as nodes of the figure and the feeders are as sides[2]. Using equivalent load model stands for load between two switches. Then distribution system net mathematical model can be got. When there is a fault in distribution system, DGs supply power in the form of isolated island of electricity with opening GDs' grid-connected switches.

2.2. Mathematics model for service restoration in distribution system with dgs

(1) Objective Function

When large scale blackout happens, it is an important aspect that how to restore loads as many as possible, considering users' loads priority. So restoring loads capacities are used as to objective function:

$$\text{Max } f = \sum_{i \in N} \lambda Li \quad (1)$$

where N is as $\{1,2,3,\dots\}$; Li is the capacity for the i th restoring load; λ is the i th load priority.

The direct purpose for network reconfiguration is to reduce net losses in normal condition of

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