RELIABILITY EVOLUTION IN DISTRIBUTION SYSTEM USING EVOLUTIONARY TECHNIQUES

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ABSTRACT

The purpose of this paper is to examine issues re-lated to the distribution system reliability improvement using nature inspired technologies like PSO (Particle swarm optimisation),GA (Genetic algorithm),Ant Colony Optimisation, Diffusion Algorithm, Artificial Bee Colony, Intelligent Water Drop, Hybrid Particle Swarm Optimization, Max-Min Particle Swarm Optimization etc.In this paper the main focus is on the improvement of reliability by taking inspiration from the collective behaviours of social insects and other animal societies. Distributed Generation (DG) is a promising solution to many power system problems such as voltage regulation, power loss, etc so the main purpose of this paper is to reduce the losses and improve the system reliability. In this paper the reliability is improve by calculating reliability indices like SAIFI, SAIDI etc.

Keywords: Distribution System, Evolutionary Techniques, Genetic Algorithm, Particle Swarm Optimization, Reliability, Reliability Indices.

I. INTRODUCTION

Reliability is associated with unexpected failures of products or services and understanding why these failures occur. This is the main purpose to improving reliability [1]. The main reasons why failures occur include:
The product is not fit for purpose or more specifically the design is inherently incapable, the item may be overstressed in some way and Failures can be caused by wear-out etc. Reliability in distribution system is the ability of system to full fill the requirement of costumer related to electricity [2].

1.1 Why Is Reliability Important?

Reliability is important because if any system is unreliable then number of unfortunate consequences and therefore for many products and services is a serious threat [3]. For example poor reliability can have implications for: Safety, Competitiveness, Profit margins, Cost of repair and maintenance, Delays further up supply chain Reputation, Good will.

1.1.1 Key Points

- Reliability is a measurement of uncertainty and therefore estimating reliability means using statistics and probability theory.
- Reliability is quality over time.

- Reliability must be designed into a product or service
- Most important aspect of reliability is to identify cause of failure and eliminate in design if possible otherwise identify ways of accommodation.
- Reliability is defined as the ability of an item to perform a required function without failure under stated conditions for a stated period of time [4].

1.2 Distribution System Reliability

Power system reliability has two aspects: system adequacy and system security [5]. The present work is concerned only with system adequacy. The three functional zones: generation, transmission and distribution are combined to give three hierarchical levels: HL-I, HL-II and HL-III for reliability evaluation of power systems. HL-I includes only the generation facilities. HL-II includes both generation and transmission facilities. HL-III includes all three functional zones. Reliability analysis of HL-III is most complex because it includes all three functional zones of power system. For this reason the distribution functional zone is analyzed as separate entity. The objective of the HL-III study is to obtain suitable reliability indices at consumer load point [6].

1.3 Distributed Generation

Distributed generation plays an important role in improving the reliability of distribution system. Many definitions and terms are used to define distributed generation. In Anglo- Saxon countries, it is termed as "Embedded Generation ", in North America it is termed as "Dispersed Generation" and in Europe and other parts of Asia it is termed as "Decentralized Generation" [7]. The term "Embedded Generation" is used to mean the concept of generation embedded in the distribution network. The International Energy Agency (IEA) has defined the distributed generation as a generating plant serving a customer on-site or providing support to a distribution network, connected to the grid at distribution level voltage. It includes small (and micro) turbines, fuel cells and photovoltaic cells etc [8].

1.4 Review of Literature

In the research of Dr. Robert P. Broad water, Dr. Ira Jacob the evolution of power system reliability Analysis improvements with distributed generators while satisfying Equipment power handling constraints. In this research, a computer Algorithm involving pointers and linked list is developed to analyze the power system reliability. This algorithm needs to converge rapidly as it is to be used for systems containing thousands of components. So an efficient "object-oriented" computer software design and implementation is investigated [9].
In the research of MARK RAWSON The California Public Utilities Commission (CPUC) has identified the costs and benefits of distributed generation (DG) as a priority issue for their new rulemaking, To understand the qualitative and quantitative nature of DG costs and benefits, the California Energy Commission (Energy Commission) has been conducting research to gain a better analytical understanding of how to calculate the costs and benefits of DG. Based on the analysis presented in this white paper, collaborative staff concludes that the following benefits and costs be addressed in this proceeding: This white paper discusses issues Energy Commission and CPUC staff, henceforth referred to as collaborative staff, has uncovered regarding the costs and benefits of DG. These issues are presented to support the CPUC's scoping memo. It should be noted that collaborative staff is not recommending a specific methodology(s) or model(s) in this paper [10].

In the research of M. Abbagana , G. A. Bakare , I. Mustapha 1,B.U.Musa -Distributed and disperse generation of electricity have been used to address economical and environmental challenges associated with centralized generation of electricity. This paper aims to minimize the power losses and improve the voltage profile of power distribution system by determining the optimal location and size of two Distributed Generation (DG) units. Differential Evolution (DE) technique is used for optimizing the formulated problem. Performance of the technique is tested on IEEE 33 bus radial distribution system consisting of 32 sections and six different scenarios were created by varying the DE parameters. MATPOWER and MATLAB software were used for the simulation. The results show that proper placement and size of DG units can have a significant impact on system loss reduction and voltage profile improvement. On the other hand, improper choice of size would lead to higher losses [11].

In the research of M.PADMA LALITHA-Distributed Generation (DG) is a promising solution to many power system problems such as voltage regulation, power loss, etc. This paper presents a new methodology using a new population based meta heuristic approach namely Artificial Bee Colony algorithm(ABC) for the placement of Distributed Generators(DG) in the radial distribution systems to reduce the real power losses and to improve the voltage profile. A two-stage methodology is used for the optimal DG placement. In the first stage, single DG placement method is used to find the optimal DG locations and in the second stage, ABC algorithm is used to find the sizes of the DGs corresponding to maximum loss reduction. The proposed method is tested on standard IEEE 33-bus test system and the results are presented and compared with different approaches available in the literature. The proposed method has outperformed the other methods in terms of the quality of solution and computational efficiency. Keywords: DG placement, Meta heuristic methods, ABC Algorithm, loss reduction, radial distribution [12].

II. TECHNIQUES USED

In the reliability improvement there are various types of techniques used. All techniques are described one by one:

2.1 Swarm Intelligence

Swarm intelligence is a computational intelligence technique to solve complex real-world problems. It involves the study of collective behaviour of individuals in a population who interact locally with one another and with their environment in a decentralised control system. Swarm intelligence is the collective behaviour of a group of animals, social insects such as ants, bees, and termites that are each following very basic rules. An artificial-intelligence approach to problem solving using algorithms based on the self-organized collective behaviour of social insects. Swarm intelligence is the discipline that deals with natural and artificial systems composed of many individuals that coordinate using decentralized control and self-organization. In particular, the discipline focuses on the collective behaviours that result from the local interactions of the individuals with each other and with their environment [13].

2.2 Particle Swarm Optimization

Main Goal of Optimization Find values of the variables that minimize or maximize the objective function while satisfying the constraints. Particle Swarm Optimization based on the collective behaviour of decentralized, self-organized systems. The expression was introduced by Gerardo Beni and Jing Wang in 1989, in the context of cellular robotic systems. Natural examples of SI include ant colonies, bird flocking, animal herding, bacterial growth, and fish schooling. Particle Swarm Optimization works- PSO is initialized with a group of random particles (solutions) and then searches for optimal by updating generations. Particles move through the solution space, and are evaluated according to some fitness criterion after each time step. In every iteration, each particle is updated by following two "best" values. The first one is the Pbest and second one is Gbest [14].

2.3 Genetic Algorithm

Genetic Algorithms (GAs) are adaptive heuristic search algorithm based on the evolutionary ideas of natural selection and genetics. As such they represent an intelligent exploitation of a random search used to solve optimization problems. The basic techniques of the GAs are designed to simulate processes in natural systems necessary for evolution; especially those follow the principles first laid down by Charles Darwin of "survival of the fittest." Since in nature, competition among individuals for scanty resources results in the fittest individuals dominating over the weaker ones better than conventional Algorithm in that it is more robust. Unlike older AI systems, they do not break easily even if the inputs changed slightly, or in the presence of reasonable noise. Also, in searching a large state-space, multi-modal state-space, or n-dimensional surface, a genetic algorithm may offer significant benefits over more typical search of optimization techniques [15].

2.4 Differential Evolution

Global optimisation is necessary in fields such as engineering, statistics and finance. But many practical problems have objective functions that are non-differentiable, non-continuous, non-linear, noisy, flat, multi-dimensional or have many local minima, constraints or stochasticity Such problems are difficult if not impossible to solve analytically DE can be used to find approximate solutions to such problem. DE is used for multidimensional real-valued functions but does not use the gradient of the problem being optimized, which means DE does not require for the optimization problem to be differentiable as is required by classic optimization methods such as gradient descent and quasi-Newton methods. DE can therefore also be used on optimization problems that are not even continuous, are noisy, change over time, etc [16].

2.5 Cultural Algorithms

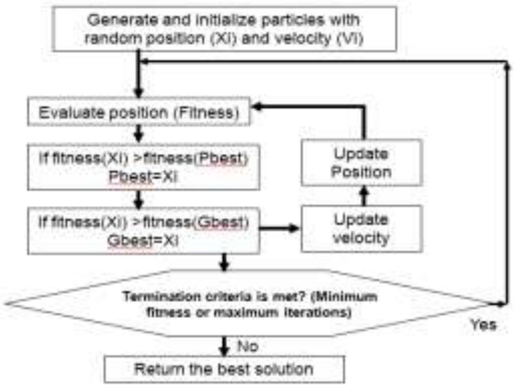
The Cultural Algorithm is an extension to the field of Evolutionary Computation and may be considered a Meta-Evolutionary Algorithm. It more broadly belongs to the field of Computational Intelligence and Met heuristic. It is related to other high-order extensions of Evolutionary Computation such as the Mimetic Algorithm. The focus of the algorithm is the Knowledgebase data structure that records different knowledge types based on the nature of the problem. For example, the structure may be used to record the best candidate solution found as well as generalized information about areas of the search space that are expected to payoff (result in good candidate solutions). This cultural knowledge is discovered by the population-based evolutionary search, and is in turn used to influence subsequent generations. The acceptance function constrains the communication of knowledge from the population to the knowledge base [17].

2.6 Ant Colony Optimization

Ant colony optimization (ACO) is a Swarm Intelligence technique which is inspired from the foraging behaviour of real ant colonies [18]. The ants deposit pheromone on the ground in order to mark the route from the nest to food that is followed by other members of the colony. ACO exploits an optimization mechanism for solving discrete optimization problems in various engineering domain. The ACO differs from the classical ant system in the sense that here the pheromone trails are updated in two ways. Firstly, when ants construct a tour they locally change the amount of pheromone on the visited edges by a local updating role. Secondly, after all the ants have built their individual tours, a global updating rule is applied to modify the pheromone level on the edges that belong to the best ant tour found so far. An artificial Ant Colony System (ACS) is an agent-based system, which simulates the natural behaviour of ants and develops mechanisms of cooperation and learning. ACS was proposed by Dorigo et al. in 1997 as a new heuristic technique to solve combinatorial optimization problems. It is found to be both robust and versatile in handling a wide range of combinatorial optimization problems [19][20].

2.7 Artificial Bee Colony

Artificial Bee Colony (ABC) technique is a swarm based metaheuristic technique. It was introduced by Karaboga in 2005 [21]. It simulates the foraging behaviour of honey bees. The technique has three phases namely employee bee, onlooker bee and scout bee. In the employed bee and the onlooker bee phases, bees exploit the sources by local searchers in the neighbourhood of the solutions selected based on deterministic selection. Scout bee phase is an analogy of abandoning exhausted food sources in the foraging process, solutions that are not beneficial anymore for search progress are abandoned and new solutions are inserted instead of them to explore new regions in the search space. The technique has a well-balanced exploration and exploitation ability [22].



Basic PSO flow chart

III. RELIABILITY INDICES

Performance indices are the record of past data. Because on the basis of past we plan for our present. the reliability are of two types qualitative reliability and quantitative reliability Quantitative reliability evaluation of a distribution system can be divided into two basic segments; measuring of the past performance and predicting the future performance [23]. Some of the basic indices that have been used to assess the past performance are;

•System Average Interruption Frequency Index (SAIFI)

•System Average Interruption Duration Index (SAIDI)

•Customer Average Interruption Duration Index (CAIDI)

•The Average Service Availability Index {Unavailability} (ASAI) {ASUI}

•Energy not supplied (ENS)

Past performance statistics provide valuable reliability profile of the existing system. However, distribution planning involves the analysis of future systems and evaluation of system reliability when there are changes in; configuration, operation conditions or in protection schemes. This estimates the future performance of the system based on system topology and failure data of the components. Due to stochastic nature of failure occurrence and outage duration, it is generally based on probabilistic models. The basic indices associated with system load points are failure rate, average outage duration and annual unavailability. SAIFI indicates how often an average customer is subjected to sustained interruption over a predefine time interval where as SAIDI indicates the total duration of interruption an average customer is subjected for a predefined time interval. CAIDI indicates the average time 8required to restore the service. ASAI specifies the fraction of time that a customer has received the power during the predefine interval of time and is vice versa for ASUI. ENS specifies the average energy the customer has not received in the predefined time [24].

3.1 Customer Based Indices

The Utilities commonly use the following two reliability indices for frequency and duration to quantify the performance of their systems [25].

(i) System Average Interruption Frequency Index (SAIFI) is designed to give Information about the average frequency of sustained interruptions per customer over a predefined area.

$$\text{SAIFI} = \frac{\text{Total number of custumer interruption}}{\text{Total number of custumer served}}$$

(ii) System Average Interruption Duration Index, (SAIDI) is commonly referred to as Customer minutes of interruption or customer hours, and is designed to provide Information about the average time that the customers are interrupted-

$$\text{SAIDI}= \frac{\text{Sum of customer interruption duration}}{\text{Total number of custumer served}}$$

(iii) Customer Average Interruption Duration Index (CAIDI) is the average time needed to restore service to the average customer per sustained interruption-

$$\text{CAIDI}= \frac{\text{Sum of customer interruption duration}}{\text{Total number of custumer interruptions}}$$

(iv) Customer Average Interruption Frequency Index (CAIFI) is designed to show trends in customers interrupted and helps to show the number of customers Affected out of whole customer base-

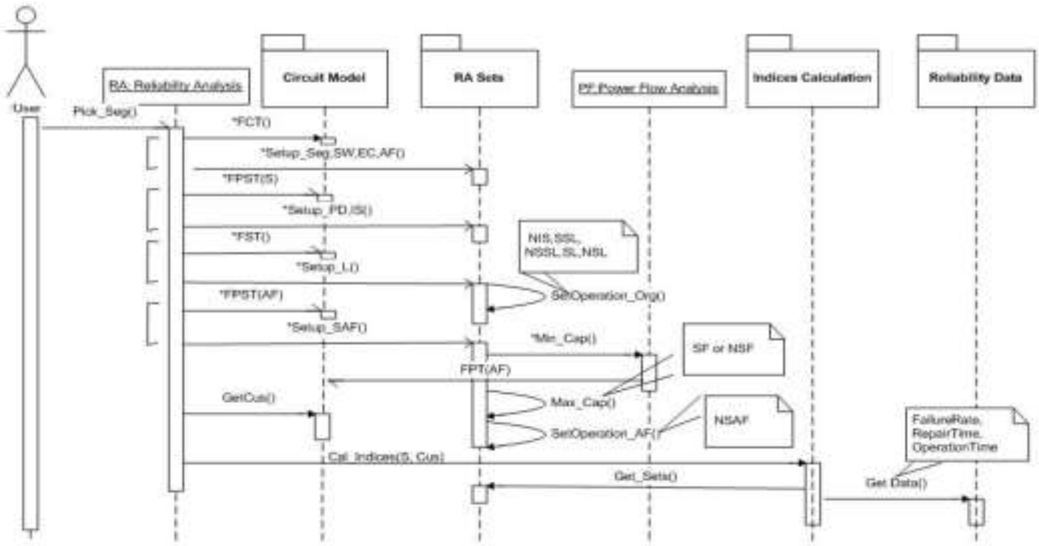
$$CAIFI = \frac{Total\ number\ of\ costumer\ interrupted}{Number\ of\ custumer\ affacted}$$

(v) Average Service Availability Index (ASAI)-

$$ASAI = \frac{Custumer\ hours\ of\ available\ service}{custumer\ hours\ demanded}$$

IV. FIGURE

Reliability Analysis Algorithm Sequence diagram-



V.TABLE-COMPARATIVE ANALYSES OF VARIOUS EVOLUTIONARY TECHNIQUES

Comparative analyses of evolutionary techniques of are summarized in Table. In particular, advantages, limitations, issues etc are analyzed and compared to the other techniques. Here we discuss mainly 5 techniques.

S.No.	Technique	Issues	Advantages	Limitation
1.	GENETIC ALGORIHM (GA)	Window size, Two point cross over, Evolution Period, Max stale period	Minimizes execution time & communication cost &maximizes average processor utilization & system throughput	Incur extra storage and processing requirement at the scheduling node The saving may out weight the extra overhead considering the ever decreasing cost of storage and processing power[26][27]
2.	PARTICLE SWARM OPTIMIZATION (PSO)	Makespan,cost, Deadline		

			It is very simple , have no overlapping and mutation calculation, it adopts the real no. code and it is decided directly by the solution[28]	It suffers from the problem of premature convergence, particularly in case of multimodal optimization problems[29]
3.	ARTIFICIAL BEE COLONY (ABC)	Colony size, maximum cycle number and limit	It produces better results on multimodal and Multidimensional optimization problems. It is as simple and flexible as PSO and also employs less control parameters	It is found effective only in solving small to medium sized generalization assignment problems not for large and complex problem[30]
4.	ANT COLONY OPTIMIZATION (ACO	Execution time, Maximum execution time, idle time.	Inherent parallelism; Positive feedback accounts for rapid discovery of good solution; Efficient for TSP.	Theoretical analysis is difficult; Sequences of random decision decisions; Probability on distribution changes by iteration;
5.	DIFFUSION ALGORITHM (DA)	It performs better in terms of time taken to balance the load, Minimizing the load variance among the nodes and maximizing the throughput.	Reducing communication overhead	It is difficult to provide clean general solution to this problem.

VI. CONCLUSION

This paper is the review paper of my thesis topic, in this review paper, we have presented a reliability analysis with the help of evolutionary techniques. In this paper we worked on improvement of reliability. in this paper we improve the reliability by calculating reliability indices, this section is also presented here. for reliability improvement there are various techniques which are used by many authors in there research papers like-genetic algorithm, Particle Swarm Optimization, Ant Colony Optimization, Diffusion Algorithm, Tabu Search, Intelligent Water Drop, Artificial Bee Colony etc.but the main work of my topic is depend on the two techniques, Particle swarm optimization, Genetic Algorithm .In this paper the comparison between many intelligent techniques is also presented. The main work of reliability improvement in distribution system is based on Particle swarm optimization and Genetic algorithm because these techniques are based on social-psychological principles and provides insights into social behaviour as well as contributing to engineering applications.

Genetic Algorithm is used because of following advantages-

1) These techniques minimizes execution time and communication cost.
2) Maximizes average processor utilization and system through output.

Particle swarm optimization Algorithm is used because of following advantages-

1) It is very simple, have no overlapping and mutation calculation.
2) It adopts the real number code and it is decided directly by the solution.

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