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Fault Pheromone Trail Evaporation of Power Distribution Networks using Ant Colony Optimization

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Abstract

The paper presents an ACO Based Pheromone Trail Evaporation method for fault searching in Power Distribution Networks.ACO Based Pheromone Trail Evaporation method is 'co-operative agent approach', which is inspired by the convergence rate and behavior of real ant colonies for finding a shortest path to reach food. Hence, in the proposed method is a set of co-operative agents called 'ants' co-operates to find a better solution for evolutionary fault searching. The ACO Based algorithm applied for better way for finding fault behavior and point of fault is evaluated on IEEE, 30, 52,190 Test bus systems. The proposed approach is compared with a normal conventional fault in power distribution network.

Keywords: *Fault Search, Ant Colony Optimization, Pheromone Trail Evaporation, Power Distribution Networks, co-operative agent approach*

1. Introduction

Power system places a prominent role in nation's progress. Present durable conditions, they are regretted and effected by different type of tribulations. Almost every power system was caused by faults, unbalanced load conditions, less power factor occurrence and voltage fluctuations like swell and sag, *etc.* Apart from all these, the power system was affected in utmost cases with fault conditions. In different research articles many authors are abounded the different assumptions are symmetrical to the proposed article. In this paper, we described the methodology to find fault occurrence in test power system [3]. Many articles initiate the reduced techniques and optimizations and detection techniques for fault behavior. The proposed paper explains the shortcut method to find the fault in anatomies manner. Basically, Ant colony optimization (ACO) is based on the cooperative behavior of real Ant colonies, which are able to find the shortest path from their nest to a Modified source [2, 1]. The Ant colony optimization process can be explained by representing the optimization problem as a multilayered graph, in that Ant conditions are replaced by Ants and Modified source is test system. Where the number of layers is equal to the number of design variables and the number of nodes in a particular layer is equal to the number of discrete values permitted for the corresponding design variable [3]. Thus each node is associated with a permissible discrete value of a design variable. Proposed figure in section as follows, denotes a problem with four design variables with five permissible discrete values for each design variable, The ACO based algorithm of fault pheromone trail evaporation can be explained in the following 2 and 3 sections [4]. Let the proposed colony consists of N Ants and the proposed algorithm explains the comparison an ant with fault, food with a power system etc.

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2. Ant Colony Optimization for Fault Identification

The Faults start at the home node, travel through the various layers from the first layer to the last or final layer, and end at the destination node in each cycle or iteration. Each Fault can select only one node in each layer in accordance with the state transition rule given by Equation (1). The nodes selected along the path visited by a Fault represent a candidate solution. For example, a typical path visited by a Fault is shown by thick lines in Figure 1. This path represents the solution (x_{12}, x_{23}, x_{31}, x_{45}, x_{56}, and x_{64}). Once the path is complete, the Fault deposits some pheromone on the path based on the local updating rule given by Eqution (3). When all the Faults complete their paths, the pheromones on the globally best path are updated using the global updating rule described by Equations (1) and (2). In the beginning of the optimization process (i.e. in iteration 1), all the edges or rays are initialized with an equal amount of pheromone. The optimization process is terminated if either the pre-specified maximum number of iterations is reached or no better solution is found in a pre-specified number of successive cycles or iterations. The values of the design variables denoted by the nodes on the path with largest amount of pheromone are considered as the components of the optimum solution vector. In general, at the optimum solution, all Faults travel along the same best (converged) path.

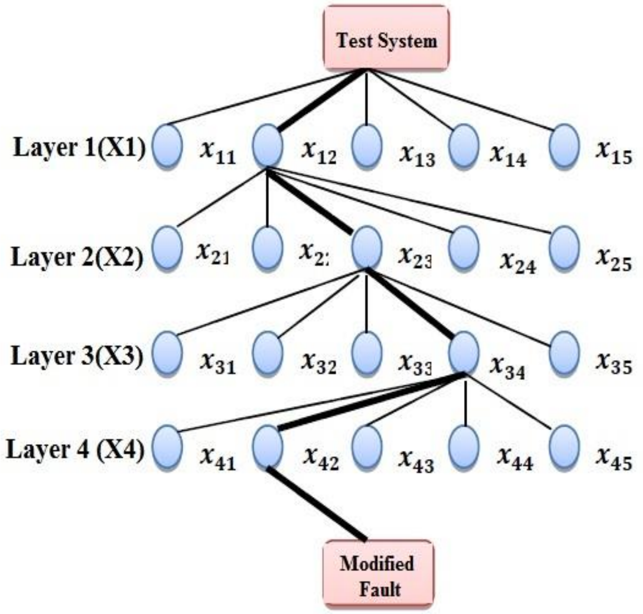

Figure 1. Fault Based Multilayer Layer ACO network

3. Fault Searching Behavior

A Fault k, when located at node i, uses the pheromone trail τ_{ij} to compute the probability of choosing j as the next node

$$P_{ij}^{(K)} = \begin{cases} \dfrac{\tau_{ij}^{\alpha}}{\sum_{j \in N_i^{(K)}} \tau_{ij}^{\alpha}} & if\ j \in N_i^{(K)} \\ 0\ if\ j \nexists\ N_i^{(K)} & \end{cases} \quad \text{.........} \ (1)$$

Where α denotes the degree of importance of the pheromones and $N_i^{(K)}$ indicates the set of neighborhood nodes of Fault k when located at objective i. Then beside of all objectives i contain all the nodes directly connected to node i accept the predecessor node (i.e. the last node visited before i). This will prevent the Fault from returning to the same node visited immediately before node i. A Fault travels from node to node until it reaches the destination (Modified) node is updated as follows

$$\tau_{ij} \leftarrow \tau_{ij} + \Delta \tau^{(K)} \quad \ldots\ldots\ldots (2)$$

Due to the incremental changes in the proto type phenomenon, the critical nature of this arc being selected by the increasing forthcoming Fault condition.

4. Proposed Technique for Fault Detection

When a Fault k moves to the next node, the pheromone evaporates from all the arcs *ij* according to the relation

$$\tau_{ij} \leftarrow (1\text{-}p)\,\tau_{ij} \;;\quad \forall (i, j) \in A \quad \ldots\ldots\ldots\ldots (3)$$

Where $p \in (0, 1)$ is a parameter and A denotes the segments or arcs traveled by Fault k in its path from home to destination. The decrease in pheromone intensity favors the exploration of different paths during the search process. This favors the elimination of poor choices made in the path selection. This also helps in bounding the maximum value attained by the critical procedure. A step is process of a complete description of Fault's movement, pheromone evaporation and pheromone deposit. After all the Faults return to the home node (nest), the pheromone information is updated according to the relation

$$\tau_{ij} = (1\text{-}p)\,\tau_{ij} + \sum_{K=1}^{N} \Delta \tau_{ij}^{(K)} \ldots\ldots\ldots (4)$$

Where $\rho \in (0, 1)$ is the evaporation rate (also known as the pheromone decay factor) and $\tau_{ij}^{(K)}$ is the amount of pheromone deposited on arc *ij* by the best Fault k. The goal of pheromone update is to increase the pheromone value associated with good or promising paths. The pheromone deposited on arc *ij* by the best Fault is taken as

$$\Delta \tau_{ij}^{(K)} = Q / L_K \ldots\ldots\ldots (5)$$

Where Q is a constant Fault and L_k is the length of the path traveled by the k^{th} Fault (in the case of the travel from one city to another in a traveling salesman problem). Equation (5) can be implemented as

$$\Delta \tau_{ij}^{(K)} = \begin{cases} \frac{\zeta f_{best}}{f_{wrost}} ; if\ (i, j) \epsilon global\ best\ tour \\ 0; other\ wise \end{cases} \ldots\ldots\ldots (6)$$

Where f_{worst} is the worst value and f_{best} is the best value of the objective function among the paths taken by the N Faults, and ζ is a parameter used to control the scale of the global updating of the pheromone. The larger the value of ζ, the more pheromone deposited on the global best path, and the better the exploitation ability. The aim of Equation (5) is to provide a greater amount of pheromone to the tours (solutions) with better objective function values.

5. Proposed Algorithm for Fault Detection

The orentational procedure of ACO algorithm for solving a minimization problem can be summarized as follows

Step 1

Assume a suitable number of Faults in the colony (N). Assume a set of permissible discrete values for each of the n design variables. Denote the permissible discrete values of the design variable x_i as x_{il} , $x_{i2}, \ldots, x_{ip}$ and ($i = 1, 2, \ldots, n$). Assume equal amounts of pheromone $\tau_{ij}{}^{(1)}$ initially along all the arcs or rays (discrete values of design variables) of the multilayered graph shown. The superscript to τ_{ij} denotes the iteration number.

For simplicity, $\tau_{ij}{}^{(1)}$ can be assumed for all arcs *ij*. Set the iteration number i = 1

Step 2

(a) Compute the probability (p_{ij}) of selecting the arc or ray (or the discrete value) x_{ij} as

$$P_{ij} = r_{ij}{}^{(l)} / \sum_{m=1}^{p} \tau_{lm}{}^{(l)} ;\ i= 1, 2, \ldots, n ; j= 1, 2, 3, \ldots, p \quad \ldots\ldots (7)$$

Which can be seen to be same as Equation (1) with $\alpha = 1$.

A larger value can also be used for α.

(b) The specific path (or discrete values) chosen by the kth Fault can be determined using random numbers generated in the range (0, 1). For this, we can find the cumulative probability ranges associated with different paths of Figure 1 based on the probabilities given by Equation (7). The specific path chosen by Fault k will be determined using the roulette-wheel selection process in step 3.

Step 3

(a) Generate N random numbers r_1, $r_2 \ldots r_N$ in the range (0, 1), and one for each Fault. Determine the discrete value or path assumed by Fault k for variable i as the one for which the cumulative probability range (found in step 2) includes the value r_i .

(b) Repeat step 3 for all design variables i = 1, 2, . . . , n.

(c) Evaluate the objective function values corresponding to the complete paths (design vectors $X^{(k)}$ or values of x_{ij} chosen for all design variables as i = 1, 2. . . n by Fault k, k = 1, 2. . .N) is

$$F_K = f(X^{(k)}) ;\ k= 1, 2, \ldots, N \ldots\ldots (8)$$

To obtain the better and worst paths chosen by different Faults are

$$F_{best} = K = 1, 2,3^{\,min} \ldots\ldots, N^{\{\,f}{}_{k}\,\} \ldots\ldots (9)$$

$$F_{best} = K = 1, 2,3^{\,max} \ldots\ldots, N^{\{\,f}{}_{k}\,\} \ldots\ldots (10)$$

Step 4

Test for the convergence of the process.

The process is assumed to have converged if all N number of Faults take the same best path. If convergence is not achieved, assume that all the Faults return home and start again in search of Test Power System. Set the new iteration number as i = i + 1, and update the pheromones on different arcs (or discrete values of design variables) as

$$\tau_{ij}^{(l)} = \tau_{ij}^{(old)} + \sum_k \Delta \tau_{ij}^{(K)} \quad \ldots\ldots (11)$$

Where $\tau_{ij}^{(old)}$ denotes the pheromone amount of the previous iteration left beyond the convergent process, which is written as

$$\tau_{ij}^{(old)} = (1-p)\, \tau_{ij}^{(l-1)} \ldots\ldots (12)$$

and $\Delta \tau_{ij}^{(K)}$ is the pheromone deposited by the best Fault k on its path and the summation extends over all the best Faults k (if multiple Faults take the same best path). Note that the best path involves only one arc *ij* (out of p possible arcs) for the design variable i. The evaporation rate or pheromone decay factor ρ is assumed to be in the range 0.5 to 0.8 and the pheromone deposited *is* $\Delta \tau_{ij}^{(K)}$ computed by using Equation (6).With the new values of $\Delta \tau_{ij}^{(l)}$, go to step 2. Steps 2, 3, and 4 are repeated until the process converges, *i.e.*, until all the Faults choose the same best path. In some cases, the iterative process is stopped after completing a pre-specified Maximum number of iterations (l_{max}).

6. Numerical Results

The proposed method is tested on standard IEEE 30, 52,190 test bus systems and the results shown that ACO Algorithm gives best solution when compared with fault identifications in normal condition of test system. Table 1, Table 2 and Table 3 shows the comparative results of and Figure 2 and Figure 3, Figure 4 shows the variations for different bus fault conditions. The proposed figures show comparison between number of iterations and loss occurrence.

For IEEE-30 Bus System
NG= 6, NL=14, NB=23, NTR=3

Table 1. Comparison of Fault Pheromone Trail Evaporation for IEEE-30 Bus

	Fault Pheromone Trail Evaporation	
	Abnormal	ACO
Number of Iterations	75	65
Population Size	5	5
Time taken in (sec)	18.6	13.8
Loss	9.65	8.63
Efficiency (%)	67	73
Behavior	Normal	Good

For IEEE-52 Bus System
NG= 8, NL=19, NB=27, NTR=5

Table 2. Comparison of Fault Pheromone Trail Evaporation for IEEE-52 Bus

	Fault Pheromone Trail Evaporation	
	Abnormal	ACO
Number of Iterations	125	100
Population Size	10	10
Time taken in (sec)	34	32.2
Loss	22.67	18.9
Efficiency (%)	56	64
Behavior	Normal	Good

For IEEE-190 Bus System
NG= 16, NL=32, NB=34, NTR=9

Table 3. Comparison of Fault Pheromone Trail Evaporation for IEEE-190 Bus

	Fault Pheromone Trail Evaporation	
	Abnormal	ACO
Number of Iterations	200	186
Population Size	15	15
Time taken in (sec)	56	42
Loss	35.3	32.1
Efficiency (%)	55	58
Behavior	Normal	Good

The following results were obtained for three deferent busses for normal fault occurrence and Ant Colony Optimization

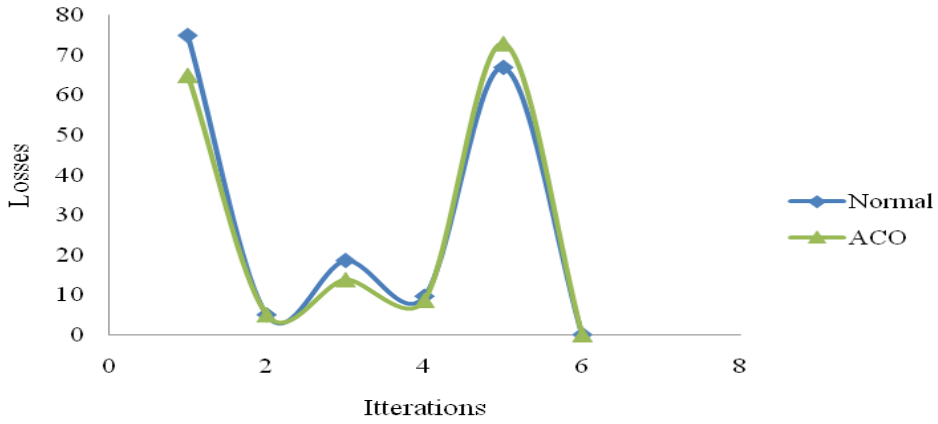

Figure 2. Convergence rate of IEEE-30 Bus Power System

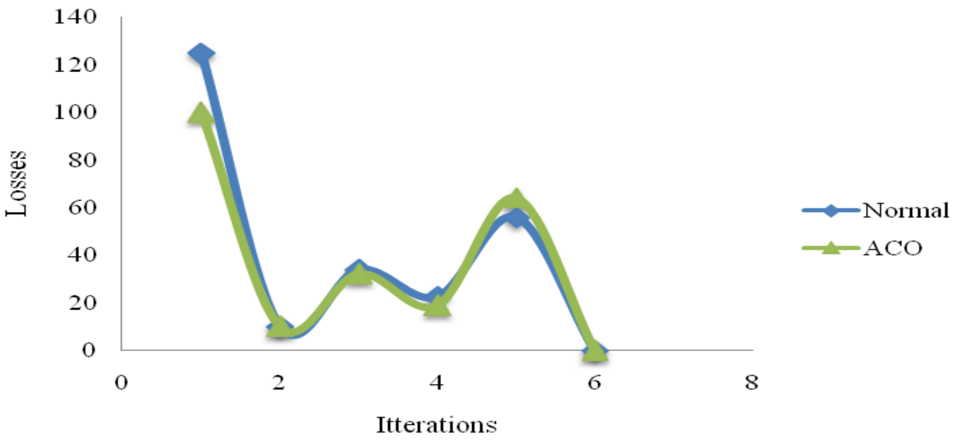

Figure 3. Convergence rate of IEEE-52 Bus Power System

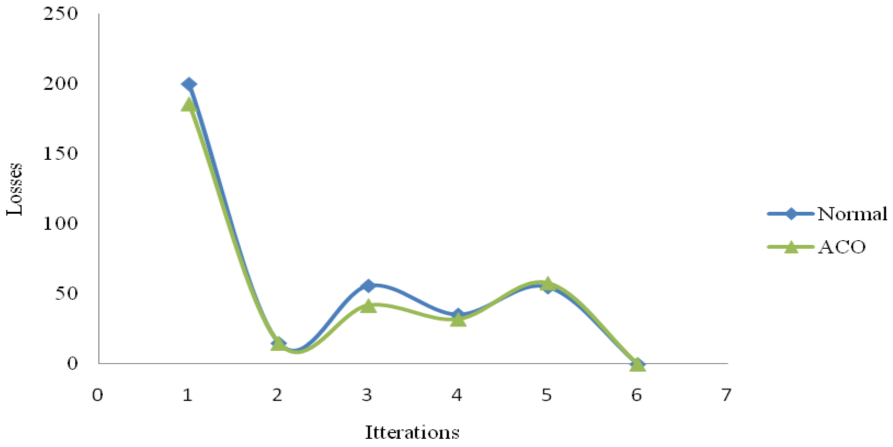

Figure 4. Convergence rate of IEEE-190 Bus Power System

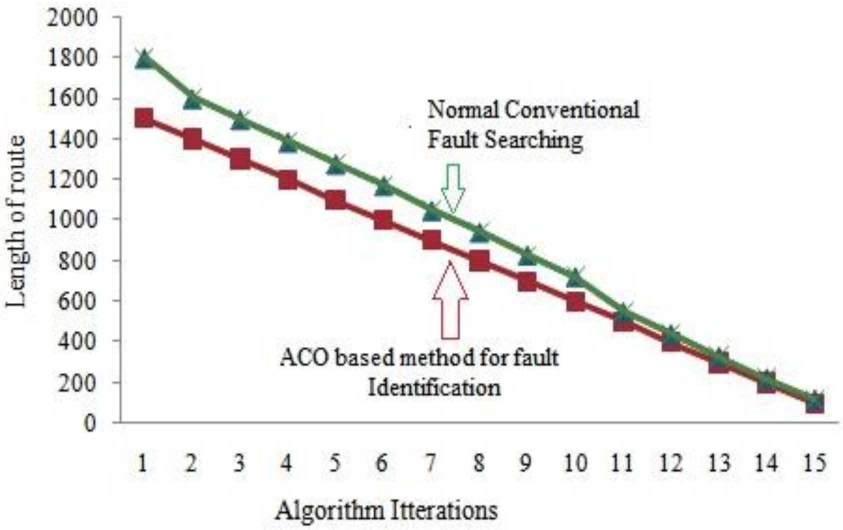

Figure 5. Comparison between Conventional Fault Searching and ACO based Behavior

7. Nomenclature

NB - total number of buses
NL - total number of load buses
NG - total number of generator buses
NTR - total number of transformers
PDN-Power Distribution Networks

8. Conclusions

In this Paper ACO Algorithm has developed for determination of Fault Probability using Pheromone Trail Evaporation method. The performance of proposed algorithm demonstrated through its evaluation on IEEE 30, 52,190 Bus power system shows that ACO is able to undertake the fault searching with a fast convergence rate and future of robust computation. From the simulation study it has been found that ACO find a fault with better convergence rate than normal searching methods. Here the normal searching considered for actual status of fault behavior in PDN and the convergence rate is modified by ACO. However, the proposed method used for find qualitative fault searching behavior in Power Distribution Networks.

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References

[1] Y. H. Song and M. R Irving, “Optimization Techniques for Electrical Power Systems: Part 2 Heuristic Optimization Methods”, IEE Power Engineering Journal, (**(2001),** June, pp. 151-160.
[2] Q. H. Wu and J. T. Ma, “Genetic Search for optimal reactive power dispatch of power systems”, Proceedings of the IEE International Conference on control, vol. 1, **(1994),** pp. 717–722.
[3] Q. H. Wu, Y. J. Cao and Y. J. Wen, “Optimal Reactive power dispatch using an genetic algorithm”, International Journal of Electrical Power and Energy Systems, vol. 20, **(1998)**, pp. 564–569.
[4] M. Dorigo, V. Maniezzo and Colorni, “Positive feedback as a search strategy”, Technical report 91-016, Department of Electronic, Polytechnic of Milano, Milan, **(1991)**.
[5] M. Dorigo, V. Maniezzo and Colorni, “Ant System: Optimization by a colony of cooperating agents”, IEEE Transactions on Systems, Man, and Cybernetics-Part B, vol. 26, no. 1, **(1996)**, pp. 29-41.
[6] K. S. Pandya and S. K. Joshi, “A Survey of the Optimal Power Flow Methods”, Journal of Theoretical and Applied Information Technology (JATIT), **(2008)**, pp. 450–458.
[7] B. H. Chowdhury and S. Rahman, “A Review of Recent Advances In Economic Dispatch”, IEEE Transactions on Power Systems, vol. 5, no. 4, (**1990),** pp. 1248-1259.
[8] Z. F. Qiu, G. Deconnick and R. Belmans, “A Literature Survey of Optimal Power Flow Problems in the Electricity Market Context,” 2009 IEEE/Pes Power Systems Conference and Exposition, vol. 1-3, **(2009)**, pp. 1845-1850.
[9] A. J. Wood and B. F. Wollenberg, “Power Generation, Operation and Control”, New York, John Wiley and Sons, **(1984)**.
[10] M. Dorigo and T. Stuzel, “Ant Colony Optimization”, the MIT Press, **(2004)**.

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