Expansion Power System Transmission Using Ant Colony Optimization

IZZATASWAD BIN IBRAHIM
Faculty of Electrical Engineering
Universiti Teknologi MARA Malaysia
40450 Shah Alam, Selangor, Malaysia
e-mail: izzat_aswad@yahoo.com

***Abstraction*-This paper presents an application of ant colony optimization (ACO) to optimization the expansion transmission in power system. The main objective this proposal to find the lowest investment total cost transmission network. A 24 bus reliability test using in transmission expansion analysis, the results show that the algorithm is capable to deliver good solutions for relatively large systems**[1]**. Ant colony optimization represent the behaviour of ant, when ant go outside their nest to find food, ants will leave pheromone to make pheromone such as track to came back to nest**[2]**. However ant will more interested at track have high pheromone intensity, high pheromone happen when too many ants through that** [3]**. Therefore high pheromone occurs at short distance trail.**

Keywords-Ant colony optimization (ACO)

I. INTRODUCTION *(HEADING 1)*

The development growth and opening of the new town, has affected high electricity demand that should be given to large residential areas and the building. Unstable of electricity due development caused from existing load increases this can create some areas do not receive enough electricity supply. To solve this problem, power system expansionplanning need to stabilize the load increased.Transmission network becomes important to give improve comfort of life, reducing cost and efficient transmission system purpose to solve the problem to get lowest total cost. There are various ways to get it. Each method will give different option of result.For example genetic algorithm, focus on evolution cells that are found in living thing. Chromosomes can find in cell each cell have same chromosomes. Chromosomal 'A' include genes can only be in one character codes such as hair color.

Figure 1 shown reliability 24 transmission bus systems, on cable 138kV transmission line are used from bus1, connected at bus2. As well figure1 shows the place of step down bus station at bus9 and bus10, followed bus 11 including bus 12 on each transmission line outage data there are important to consideration for repairing and maintaining the transmission line[4].

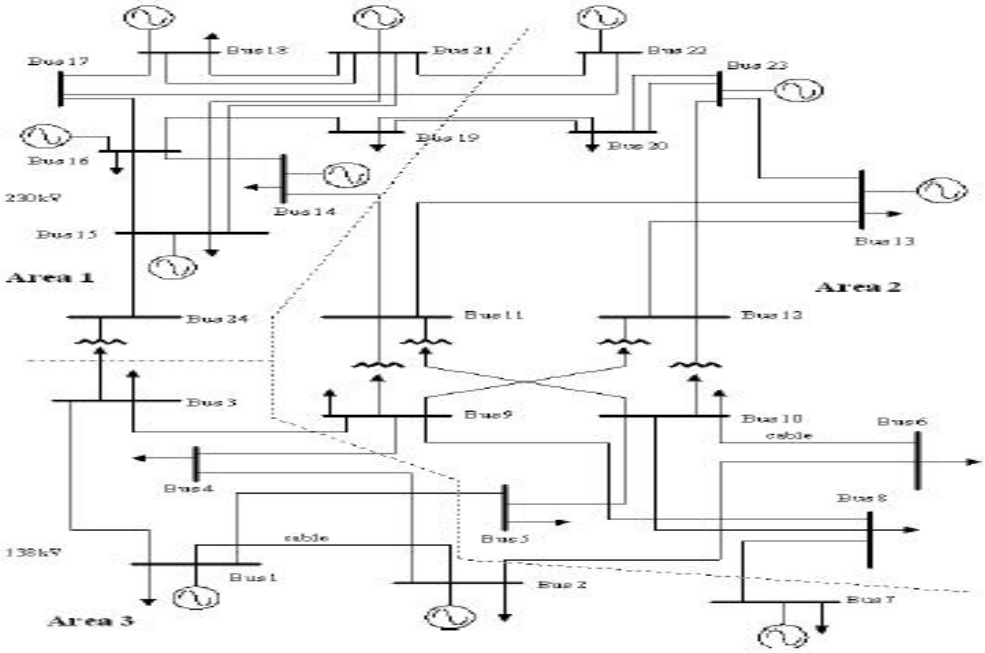


Figure1. Reliability 24 transmission bus system

II. PROBLRM FORMULATION

$$p_{ij}^{k}(t)=\frac{[\tau_{ij}(t)]^{\alpha}[\eta_{ij}(t)]^{\beta}}{\sum_{k=1}^{m}[\tau_{ik}(t)]^{\alpha}[\eta_{ik}(t)]^{\beta}} \quad (14)$$

$$\eta_{ij}=\frac{1}{b_{ij}} \quad (15)$$

$$\sum_{k=1}^{m}[\tau_{ik}(t)]^{\alpha}[\eta_{ik}(t)]^{\beta} \quad (16)$$

Where Probability ant ***k*** selects a link connection at bus ***i*** and ***j***that mean ant travel from one point to another. Furthermore τ_{ij} is the pheromone intensity that produced by ants along the way there trail and η_{ij} is the heuristic information between node ***i*** and node ***j*** created by ants travel through each node respectively. In addition, α is the relative importance of the traces and β is the relative importance of the information of heuristic. The specific heuristic information problem can derive in(15). In this case b_{ij} transmission line outage rate 1/year, Therefore the level of line with lesser outage rate has greater probability to be select.Equation (16) need to calculate like a sum, but in transmission the equation need to multiply the $[\tau_{ij}(t)]^{\alpha}$ *and* $[\eta_{ij}(t)]^{\beta}$ .Pheromone updating closely related to pheromoneunfeasible number of pheromone solution, deposited by ants.

$$\tau_{ij}(t)=(1-\rho)\cdot\tau_{ij}(t-1)+\Delta\tau_{ij} \quad (16)$$

.

ρ is a coefficient such that (1- ρ) represents the evaporation of trail and $\Delta\tau_{ij}$ is.

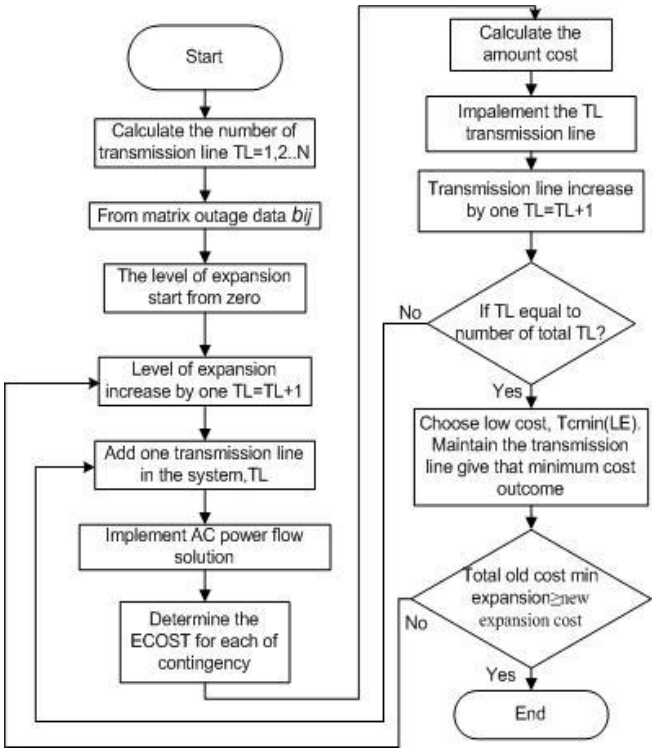
$$\Delta\tau_{ij}^{k}=\begin{cases}0.00001 & if\ k^{th}\ ant\ chooses\ path\\ 0 & otherwise\end{cases} \quad (18)$$

if *k* ant chooses path it count 0.00001 because it's did not want to become infinity for the result of pheromone intensity evaporate and to increase or decrease number of pheromone intensity[5].

III. METHODOLOGY

A. *flowchart*

This flow chart about expansion of power system by using ant colony optimization, find minimum cost.



The flow chart start from set the counter cycle at the same time, initial iteration start from zero than choose the random point *m*ants are position at nest in 24 nodes, the initial point for ant to start the tour, each 24 ant will choose a route to give a solution. Each ant start to travel form one point to one point to build feasible solution after finish their tours ant go back to their nest at starting point. Ants are guided by heuristic and pheromone information along ant tour, ants move while leaving a trail of pheromone. The amount of pheromone will evaporate by surrounding temperature then the trails continue modified by global updating rule [5]. The more pheromone in that trail, the more ants are use that trail.The level of expansion increase one by one, by adding one transmission line (TL) at transmission line connection. After that, perform AC power flow solution for every contingency because transmission line carry AC current follow by calculate the ECOST for every contingency. Continue by using formula to calculate the total cost after transmission line added in transmission network. When number of transmission line(TL) not equal to number of transmission line max(N_{TL}) the process will go to add transmission line. Next choose the lowest cost of transmission. If the old cost greater than new, the process end. Than If not the process will go to add transmission line.

B. *Data input*

The input data matrix, are used as input data in matlab. Data input help ant colony coding process performs to finding the minimum total cost for transmission line expansion. Data of outage rate is use to put in the matrix.

$$b_{ij} = \begin{array}{c} \\ 1 \\ 2 \\ 3 \\ \vdots \\ n \end{array} \begin{array}{c} \begin{array}{cccccc} 1 & 2 & 3 & \cdots & n \end{array} \\ \begin{bmatrix} 0 & x_{12} & x_{13} & \cdots & x_{ij} \\ x_{21} & \ddots & \cdots & \cdots & \vdots \\ x_{31} & \cdots & \ddots & \cdots & \vdots \\ \vdots & \cdots & \cdots & \ddots & \vdots \\ x_{ij} & \cdots & \cdots & \cdots & x_{nn} \end{bmatrix} \end{array}$$

Figure2. Data input matrix

The data input matrix *n* is the number of bus, when number of data χ_{nn} the value will be zero because of the same number of point. Than value for $\chi_{12} = \chi_{21}$ must same value, because the point put at the same node. The rest will enter according the matrix data, and data with no value put zero.

C. First iteration

In ant colony system, the first step is to initialization the cycle counter (NC) is equal to zero for each combination of bus *i* and *j*.the starting case, initial pheromone start at zero and value of pheromone intensity also zero.Second step construct feasible solution, this step start the *k* is equal to one until the total number of ant *m* is equal to 24.Followed *i* bus start form one to *n, n* is number of branch in system. Next calculate the probability. Than update the best solution by using global updating rule combination at bus *i* and *j*.After that, try to find the different between pheromone using equation to updating pheromone data[4].

Cycle counter increase by one, therefore, if cycles counter less than cycle counter max this process will turn to step 2 if cycle counter greater than counter cycle max the process end.

D. Second iteration

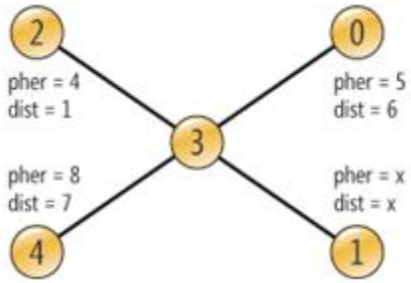


Figure3. 5 nodes with pheromone and distance

E. Updating ant information

This is the example of ant colony optimization. In this situation ant start randomly at two point, at dist=x and pher=x, than update to determining the next city.Alpha is 3 and beta is 2 specified assume. The tau value for city 1 and 3 not include because it already in trail. After all tau value are complete fill all the node. The next step convert those value to probability and place them in array label (probe).

trail				
1	2	?	?	?

$$pher = \tau_{ij}(t) \qquad \eta_{ij} = \frac{1}{b_{ij}}$$

$$\alpha = 3 \quad \beta = 2$$

$$taueta = (pher)^{\alpha} \times (1/b)^{\beta}$$

taueta				
3.47	x	64.00	x	10.45
[0]	[1]	[2]	[3]	[4]

Sum	77.92

$$p_{ij}^{k}(t) = \frac{\left[\tau_{ij}(t)\right]^{\alpha}\left[\eta_{ij}(t)\right]^{\beta}}{\sum_{k=1}^{m}\left[\tau_{ik}(t)\right]^{\alpha}\left[\eta_{ik}(t)\right]^{\beta}}$$

Probe				
0.04	0.00	0.82	0.00	0.13
[0]	[1]	[2]	[3]	[4]

F. Updating the pheromones

Pheromone is created by ants. It may regard as traces, left by ants. Pheromone will be evaporated by ambient temperature. Therefore the concentration pheromones will change following the shorter trip.

$$\Delta\tau_{ij}^{k} = \begin{cases} 0.00001 \text{ if } k^{th} \text{ ant chooses path} \\ 0 \qquad\qquad\qquad\qquad otherwise \end{cases}$$

$$\Delta\tau_{ij} = \sum_{k=1}^{m}\Delta\tau_{ij}^{k}$$

If *k* ant chooses path the value is 0.00001, its function to make the value not going to be infinity value.This also use to show the increase or decrease the pheromone.

$$\tau_{ij}(t) = (1-\rho)\cdot\tau_{ij}(t-1) + \Delta\tau_{ij}$$

Values of rho take from global parameter, the larger value of rho, the greater decrease of pheromone[5].

IV. RESULTS AND DISCUSSION

Table1: output data of ant colony of trail and value of cost

Bus	Trail	Cost\$(10^6)
1	21-18-17-16-15-24	242.9
2	7-8-10-12-13	396.41
3	2-1-5-10-11-9- 12-13-23-20-19	480.44
4	9 -11 -10 -12 -13- 23 -20- 19-16-15 -21- 18-17- 22-1 -2 -4	469.61
5	1-3-24-15	449.69
6	2-1-5-10-11-9-12-13-23-20-19-16-15-21-	352.81

	18-17-22	
7	13-23-20-19-16 -15-21-18-17-22	384.18
8	3-24	156.98
9	5-1-2-4-9-11-10-12	368.1
10	6-10-11-9-12-13-23-20-19-16-15-21-18-17	401.52
12	22-14-8-7-4-2-1-5	200.57
13	1-3-9	143.48
14	11-9-12-10-5-1-2-4	443.42
15	13-8-7-6-21-18-17	242.9
16	9-8-14-16	396.41
17	2-17-18-21-15-16-19-20-23	480.44
18	3-24-11-14-16-15-21-18-17	469.61
19	5-1-2-4-9-11-10-12	449.69
20	9-11-14-16-15	352.81
21	2-1-5-10-12-9	384.18
22	4-2-1-5-10-12-9-11-14-16	156.98
23	21-18-17	368.1
24	6-10-12-9-11-14-16	401.52

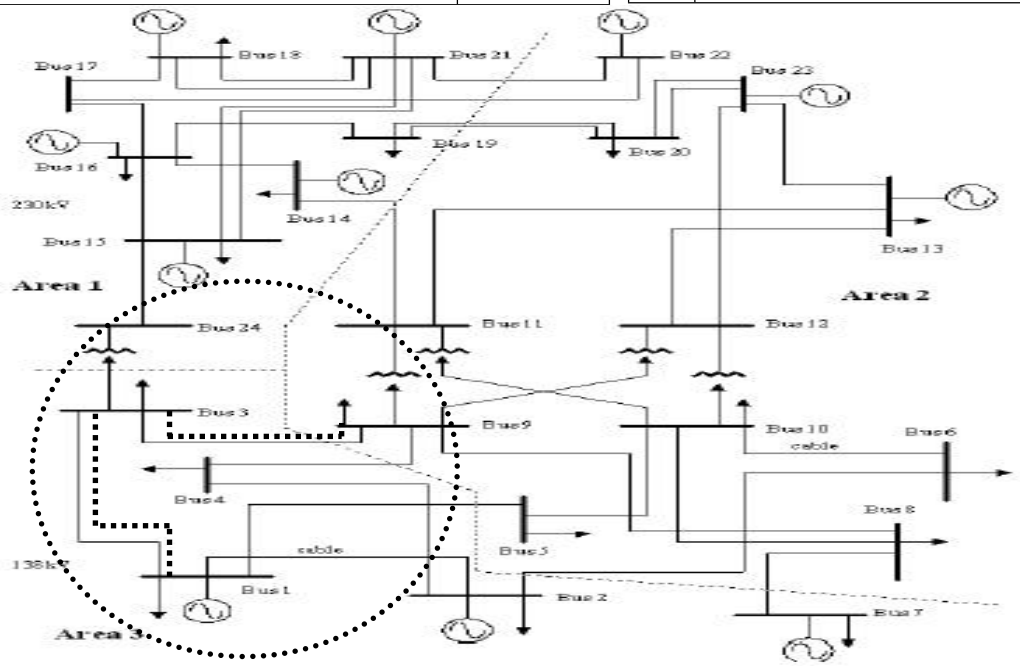


Figure4.Reliability 24 transmission bus system with double circuit transmission line

The lowest total coast produce at bus1, and bus3 followed bus9, total cost get 143.48milion base in table1. In figure4 illustrated put another transmission at bus 1,2, and 9.

V. CONCLUSION

This paper, recommend a low cost to search the transmission network by using ant colony optimization algorithm. Ant colony method has been tested with 24 bus transmission network prove that satisfaction output. Objective has been achieved with a less total cost for expansion. With ant colony also increases the option to make selection for expansion. Engineer easily can choose what type method suitable need to use to face any problem for expansion transmission line.

.

ACKNOWLEDGMENT

First of all I like to thank to Allah because give me strength and idea to finish this paper. I like to take this opportunity to thank to my parent, my lecture and supervisor mohdfuadabdullatip support me from the beginning until now, also to my friend support and help me to finish my work.

REFERENCES

[1] I. Fuchs, S. Voller, and T. Gjengedal, “Ant colony based transmission expansion developed for the Nordic Area and Great Britain,” *PowerTech, 2011 IEEE Ant Colony based Transm. Expans. Dev. Nord. Area Gt. Britain*, pp. 1–6, 2011.

[2] I. Fuchs, S. Member, T. Gjengedal, and S. Member, “Ant Colony Optimization and Analysis of Time Step Resolution in Transmission Expansion Computations for Wind Power Integration,” pp. 1–6, 1992.

[3] P. Torino and I. Elettrica, “DISTRIBUTION SYSTEMS WITH ANT COLONY SEARCH,” *Distrib. Syst. WITH ANT COLONY SEARCH*, no. August, pp. 22–26, 2005.

[4] N. F. A. Ghani, M. M. Othman, S. R. Kasim, I. Musirin, M. F. A. Latip, A. Mohammed, and A. Hussain, “Composite Power System Expansion Planning.”

[5] A. B. Stract, “A P P LICATION OF ANT CO LONY O PTIMIZATION TO TRAN SMI S SION NETWORK EX PAN SION P LANNING WITH SECURITY CON STRAINT P. Limsakul,” pp. 1–6.