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# MULTI AGENT PARTICLE SWARM OPTIMIZATION APPLIED FOR ECONOMIC DISPATCH WITH OPTIMAL POWER FLOW

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***Abstract:*** The paper deals with the real and reactive power economic load dispatch in the power systems. Optimal power flow problem is used to find an optimal point in a power system. It is used to minimize the generation cost and transmission loss depending on the constraints. In this economic dispatch Optimization problems have the linear and non-linear functions. A particle swarm optimization algorithm based on multi-agent systems is used to solve the real and reactive powers of the economic dispatch problem. Each particle in the Multi-Agent Particle swarm optimization, utilizes its swarm and increase the speed of the optimization performance. The Multi Agent Particle Swarm Optimization requires origin space, operational time and with its limitations. Multi Agent Particle swarm optimization applied to the optimal real and reactive power economic dispatch problems. Under the test, IEEE 30 bus system is used in the economic dispatch and load flow problem.

***Index Terms:*** Economic load dispatch, Optimal power flow, Multi-agent particle swarm optimization (MAPSO).

## INTRODUCTION

In Economic load dispatch problem, to determine the generating optimal cost and it should meet the load demand at minimum fuel cost with all equality and in-equality constraints. The main objective of the economic dispatch problem is to minimize the total generation cost. The loads and transmission losses in the entire network must be satisfied. Economic load dispatch and optimal power flow are the most important problems, solved in the operation of power system network. The problem has a significant influence on secure and economic operation in the real and reactive power in the power system network. The optimal power-flow calculation, which determines the controllable variables like real and reactive power outputs of the generators [1-6]. It minimizes the transmission losses satisfying the given set of physical and operating constraints. OPF problem have been proposed for solving this highly non-convex problem including Lagrange relaxation, Linear and non-linear programming, Artificial intelligence,

Newton-raphson, Quadratic programming, Interior point methods, Artificial neural network, fuzzy logic, genetic algorithm, evolutionary programming and also particle swarm optimization. The real and reactive power optimization problem is used to solve by using linear and non-linear programming models [7-13]. The

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interior-point method is used to handle the equality and in-equality constraint, it offers convenience in handling and convergence output. The other techniques to solve the optimal power flow problem like interior point linear program, quadratic program and non-linear program. Particle swarm optimization is one of the evolutionary computation techniques adopted through the simulation results of a simplified social system. It is used to found, robust in solving continuous non-linear optimization problems. The Particle Swarm Optimization (PSO) technique is used to generate highly convergence solutions within the shorter iteration time. The stable convergence characteristics of particle swarm optimization compared with other stochastic methods [14, 15]. The PSO is used for tuning some weights or parameters. The Particle swarm optimization quickly finds the superior optimal solutions in any other economic power dispatch problems. At the beginning it has more global searching ability and a local search near the end. There are some possibilities to solve the optimization problems with more local optima and to explore the local optima at the end. Since the real and reactive power optimization problems have these effects it in the power system. In the field of artificial intelligence, Agent based computation technique has explained it. There are many multi-agent based applications are used to solve the problem in that area. The system integrates multi-agent system based on particle swarm optimization. In this real and reactive power optimization problem, multi agent based particle swarm optimization approach is used. In this proposed method, PSO agent represents a particle and a solution (candidate) to the optimization problem. All agents having a lattice point in the lattice-like environment. To compute and co-operate with their neighbors, we got the optimal solution fastly. Evolution mechanism and agent interactions of PSO, using these agents live in a lattice-like environment. The MAPSO methods are having the faster convergence characteristics, higher quality solution in the reasonable execution time [16, 17]. MAPSO is used for optimal real and reactive power is tested on an IEEE 30-bus system. Thus the simulation results are much faster than other methods.

## PROBLEM FORMULATION

The optimization problem is to obtain a particular set of points, including all outputs of the power generation units, such that all equality and in-equality constraints indicate the real power balance and limitation of the power generation of each unit respectively.

### Test Case *(Optimal Generation)*

In a power system, the total fuel cost is an equal summation of all the generation units.

Optimal generation cost functions,

$$C = \min \sum_{i=1}^{Ng} f_i(P_{Gi}) \text{ \$/hr.} \tag{1}$$

where,

$C$ = optimal generation cost when the utility supplying its own load.

$f_i(P_{Gi})$ = optimal generation cost function of the $i^{th}$ generator for $P_{Gi}$ generation.

$P_{Gi}$ = power generation by the $i^{th}$ generator.

$Ng$ = number of generator connected network.

Power system constraints are,

$$\sum_{i=1}^{Ng} P_{Gi} = p_d + p_l \tag{2}$$

where,

$P_d$ = Total load demand of the system.

$P_l$ = Transmission losses in the system. (when the utility supplying its own load)

The power flow equation of the network,

$$g(|v|, \phi) = 0 \tag{3}$$

where, $|v|$ and $\phi$ is a voltage magnitude and phase angle of different buses.

The in-equality constraint on real power generation $P_{Gi}$ of each generation $i$,

$$P_{Gi}^{min} \leq P_{Gi} \leq P_{Gi}^{max} \tag{4}$$

where, $P_{Gi}^{min}$ and $P_{Gi}^{max}$ are respectively minimum and maximum value of real power generation allowed at generator $i$.

The in-equality constraint on voltage of each PQ bus

$$V_i^{min} \leq V_i \leq V_i^{max} \tag{5}$$

where, $V_i^{min}$ and $V_i^{max}$ are respectively minimum and maximum voltage at bus $i$.

Power limit on the transmission line,

$$\text{MVA } f_{p,q} \leq \text{MVA } f_{p,q}^{max} \tag{6}$$

where, $\text{MVA } f_{p,q}^{max}$ is the maximum rating of transmission line connecting bus $p$ and $q$.

## MULTI AGENT PARTICLE SWARM OPTIMIZATION ALGORITHM

### 1. Particle Swarm Optimization

Particle Swarm Optimization is motivated from the simulation of the behavior of social systems such as fish schooling and bird flocking. The PSO algorithm requires less memory because of the simplicity inherent in the above systems. The basic assumption behind the PSO algorithm is, birds find food by flocking and not individually. This leads to the assumption that information is owned jointly in flocking. The potential solution is called particles in PSO algorithm. The current optimum particles fly through the entire problem space. In problem space each particle keeps the track for the optimal solution and it has achieved so far. The fitness value is also stored i.e., this value is called $p_{\text{best}}$. The particle swarm optimization concept consists, changing the velocity of each particle towards its $p_{\text{best}}$. Acceleration is weighted, using random numbers for acceleration generated towards $p_{\text{best}}$. When a particle takes all the population as its topological neighbors, the best value is called global best and denoted as $g_{\text{best}}$. In research area and the application oriented areas, the PSO algorithm is a successful optimization method to solve the problems. Particle Swarm Optimization algorithm gives better results in a faster, cheaper than the other methods. Particle Swarm Optimization is used to solve the optimization problems.

### 2. Multiagent System

In the field of Artificial intelligence, Agent based computation is clearly explained in that particular area. In-order to achieve the goals, several agents work together in an origin called Multi-agent system. An agent having some properties like,

(a) An agent resides and performs in that particular area.

(b) In the environment an agent having perception and to interact with other agents.

(c) An agent endeavour to achieve the particular objective.

(d) Based on the learning ability, an agent is able to respond in changes.

### 3. Multi Agent Particle Swarm Optimization Algorithm

In this algorithm, Multi-Agent System and Particle Swarm Optimization are united to frame the proposed MAPSO method for solving real and reactive power problems [14]. In this optimization problem, a candidate solution is represented by an agent. Each agent fixed on a lattice-point and lives in a lattice-like environment. By self-learning process each agent competes and co-operates with their neighbors to produce high quality optimal solution**.** The evolution mechanism of Particle Swarm

Optimization, it is used to transfer of information among agents in a speedy manner. The objective function of the proposed MAPSO method defines,

***Agent and its purpose:*** In MAPSO, a solution (candidate) is given by an agent in a hand particle for the optimization problem. In this optimization problem, an agent having some fitness value in a local area environment. For solving real and reactive power optimal power flow problem, the active power loss is calculated by using its fitness value in the transmission network. The objective is to minimize the real power transmission losses and keep all the voltages within the limits. Each agent carries all control variables in real and reactive powers to be optimized in this problem.

***Environment-term:*** An environment, all agents are alive. An environment is categorized as a lattice-like structure. In each circle denoted as an agent, each agent is fixed on a lattice-point. The data represents its position in the environment.

***Local Environment-term:*** Each agent can only sense its local environment in Multi Agent System, the definition of the local environment is very important in the proposed method.

***Agents Behavioral Strategies-term:*** To achieve its purposes, each agent has some behaviors. Each agent co-operates and speedy engaged with its neighbors in the multi agent particle swarm optimization method**.** In this large environment, an agent diffuses its useful information.

## 4. Implementation of MAPSO

To simulate the agent behaviors in realistic manner, Multi agent particle swarm optimization algorithm has many different operators to be utilized. In the self-learning operator is used to reduce the computational cost. The agent can perform within the minimum fitness value in each generation of multi agent particle swarm optimization algorithm. In this economic dispatch problem, the MAPSO algorithm gives the accurate converging value and speedy optimal solution for real and reactive power.

## RESULTS

The Multi-agent Particle Swarm Optimization Algorithm is implemented in the IEEE-30 Bus test system.

### Base Case (*Optimal Generation of 6 Generating Plants*)

For the base case the optimal generation of the generating units of the utility are presented in the Table 1.The total cost of generation for the base case optimal schedule is C = 787.900 $/hr.

**TABLE 1: BASE CASE**

| | | |
|---|---|---|
| | *OUTPUT* | |
| Total Power Demand | | 290 MW |
| Power Generated | P1 | 193 MW |
| | P2 | 48 MW |
| | P5 | 14 MW |
| | P8 | 12 MW |
| | P11 | 10 MW |
| | P13 | 13 MW |
| Total Fuel Cost | | 787.900 $/hr. |
| No of Iterations | | 100 |
| Execution Time | | 1.4790 Seconds |

## APPENDIX

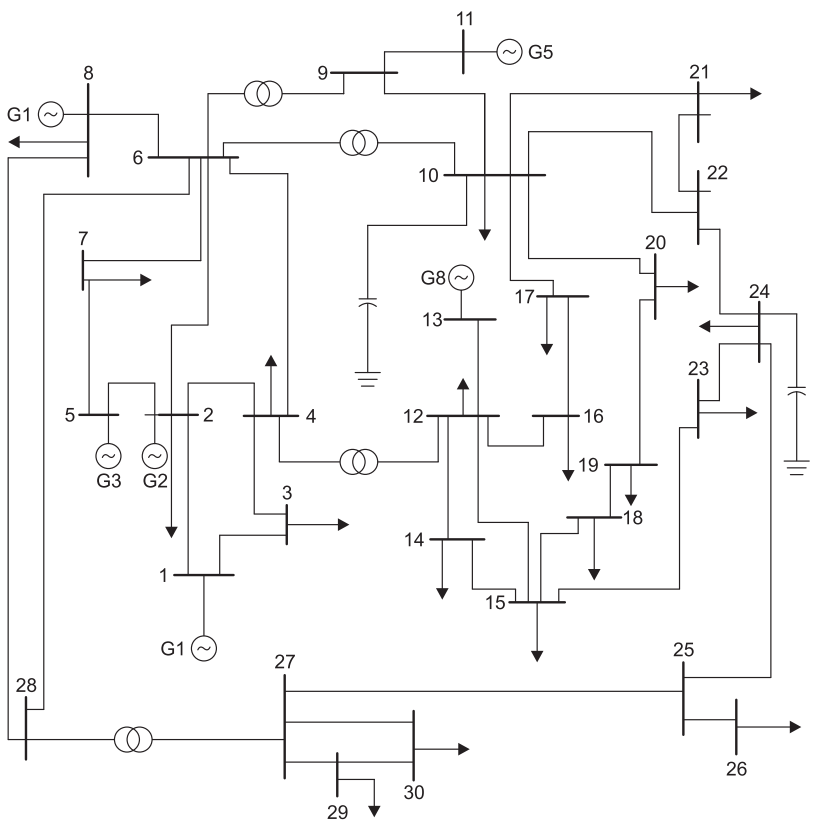


**Figure 1: Single line diagram of IEEE-30 bus test system**

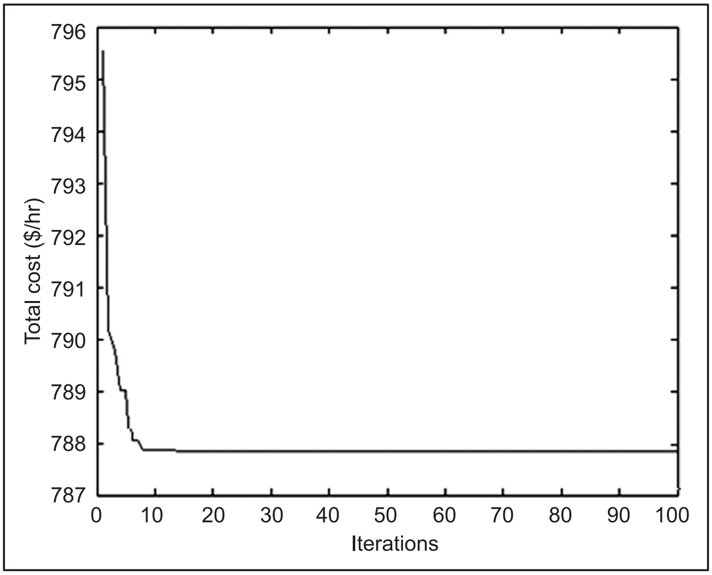


**Figure 2: Iteration vs. Total fuel cost**

## CONCLUSION

The proposed method is used for real and reactive power in the economic load dispatch problem, to determine the global optimum solution. In the search space each agent adjusts its position towards it can able to compete and co-operate with its neighbors in the environment according to Particle swarm optimization. The faster convergence properties of Multi agent particle swarm optimization algorithm is used to produce the high quality solutions. The proposed method and its performance evaluated through the IEEE 30-bus standard test system. In this economic dispatch with load flow problems, the MAPSO method of having the global search, fast convergence value and robust computation.

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