Congestion Management by Particle Swarm Optimization

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Abstract: **The electricity industry throughout the world, which has long been dominated by vertically integrated utilities, is undergoing enormous changes. The electricity industry is evolving into a distributed and competitive industry in which market forces drive the price of electricity and reduce the net cost through increased competition. The objective of deregulated power system is to provide a reliable power at competitive price. Congestion in the system would cause the objective failure. To overcome this effective congestion management s required. Congestion management is one of the key features of System Operator. There are many congestion management techniques available like operation of FACTS devices, outages of congested lines, Re-dispatching of generators, load curtailment, etc. whenever an raise in load at particular bus or an outage of line due to fault occurs in the system the line flow in the system hit its transfer limits thus causing the system to be in a congested state. In this work minimizing the line flows are taken as objective function and thus the generators are re-scheduled to elevate congestion in the system.**

I. INTRODUCTION

The electrical power supply industry around the world has experienced a period of rapid and irreversible change since the middle of 1980. the need for more efficiency in power production and delivery has led to a restructuring of the power sectors in several countries traditionally under control of federal and state governments. the privatization process in great britain is the best known example, followed by others such as spain, new zealand, argentina and chile. even in countries with privately own utilities, such as the u.s., there has been a strong drive towards deregulation and a more intense participation of third-party generation. other countries also considering the restructuring of their electricity power sector so as to introduce more competition among producers and to offer more choices for customers. those changes are concerned with the ownership and management of the industry. under deregulation, the former vertically integrated utility, which performed all the functions involved in power i.e. generation, transmission, distribution and retail sales, is dis-aggregated into separate companies devoted to each function. the electricity bill for end consumer now involves at least two components: one from the distribution and transmission network-operator responsible for the network and services, and the other from the company that generates the electrical energy. this for many decades, vertically integrated electric utilities (viu) monopolized the way they controlled, sold and distributed electricity to customers in their service territories. this monopoly involves three main sectors namely: generation company (genco), transmission company (transco) and distribution company (disco).

Monopolies could not provide services as efficiently as competitive firms. The electric power industry plans to improve its efficiency by providing a more reliable energy at least cost to customers. A competition is guaranteed by establishing a restructured environment in which customer could choose to buy from different suppliers and change suppliers as they wish in order to pay market-based rates.

II. CONGESTION

Whenever the physical or operational constraints in a transmission network become active, the system is said to be in a state of congestion. The possible limits that may be hit in case of congestion are, line thermal limits, transformer emergency ratings, us voltage limits, transient or oscillatory stability, etc. These limits constrain the amount of electric power that can be transmitted between two locations through a transmission network. Flows should not be allowed to increase to levels where a contingency would cause the network to collapse because of voltage instability.etc.

The peculiar characteristics associated with electrical power prevent its direct comparison with other marketable commodities. First, electrical energy cannot be stored in large chunks. In other words, the demand of electric power has to be satisfied on a real time basis..Due to other peculiarities, the flexibility of directly routing this commodity through a desired path is very limited. The flow of electric current obeys laws of physics rather than the wish of traders or operators. Thus, the system operator has to decide upon such a pattern of injections and take-offs, that no constraint is violated. Congestion, as used in deregulation parlance, generally refers to a transmission line hitting its limit. The ability of interconnected transmission networks to reliably transfer electric power may be limited by the physical and electrical characteristics of the systems including any or more of the following.

- Thermal limits
- Voltage limits
- Stability limits

III. IMPORTANCE OF CONGESTI0N MANAGEMENT IN THE DEREGULATED ENVIRONMENT

If the network power carrying capacity is infinite and if there are ample resources to keep the system variables within limits, the most efficient generation dispatch will correspond to the least cost operation Kirchoff's laws combined with the magnitude and location of the generations and loads, the line impedances and the network topology determine the flows in each line. In real life, however, the power carrying capacity of a line is limited by various limits as explained earlier. These power systems, security constraints may therefore necessitate a change in the generator schedules away from the most efficient dispatch. In the traditional vertically integrated utility environment, the generation patterns are fairly stable. From a short term perspective, the system operator may have to deviate from the efficient dispatch in order to keep line flows within limits. However, the financial implication of such re-dispatch does not surface because the monopolist can easily socialize these costs amongst the various participants, which in turn, are under his direct control. From planning perspective also, a definite approach can be adopted for network augmentation.

However, in deregulated structures, with generating companies competing in an open transmission access environment, the generation/flow patterns can change drastically over small time periods with the market forces. In such situations, it becomes necessary to have a congestion management scheme in place to ensure that the system stays secure; however, being competitive environment, the re-dispatch will have direct financial implications affecting most of the market players creating a set of winners and losers. Moreover, the congestion bottlenecks would encourage some strategic players to exploit the situation.

EFFECTSS OF CONGESTION

- Market inefficiency
- Market power
- Economic efficiency

CONGESTION MANAGEMENT SCHEME MUST SATISFY THE FOLLOWING

- Non discriminative
- Be transparent

IV. OPF BASED CONGESTION MANAGEMENT

The general idea of nodal pricing is to model an electricity market with its various economical and technical specifications, such as generators' cost functions, demand elasticity, generation limits, line power flow limits and optimize the system for maximizing social welfare. This problem represents one of the commonly employed formulations of Optimal Power Flow (OPF). The name OPF does not stand for any specific optimization problem, rather a number of optimization problems falls onto the OPF category, the basic aim of an OPF analysis is to reach an optimum power transfer situation without violating the network constraints. In other words, the congestion management problem, with a set of constraints representing network constraints.

The practical OPF uses a formulation wherein ac power flow equations are added to the economic dispatch as equality constraints with inequality constraints involving the flow MW, MVA or current on a transmission line and voltages at a substation bus. A version of OPF is developed that takes into account various contingencies referred to as security constrained OPF or SCOPF. OPF problems are formulated with a number of objectives. A brief list is outlined here:

- Minimize the total cost of production
- Maximize total social welfare
- Minimize total system loss
- Minimize the re-dispatch cost
- Minimize the total adjustment

V. PARTICLE SWARM OPTIMIZATION

Particle swarm optimization (PSO) is a population based stochastic optimization technique developed by Dr. Eberhart and Dr.Kennedy in 1995, inspired by social behavior of bird flocking or fish schooling.

PSO shares many similarities with evolutionary computation techniques such as Genetic Algorithms (GA). The system is initialized with a population of random solutions and searches for optima by updating generations. However, unlike GA, PSO has no evolution operators such as crossover and mutation. In PSO, the potential solutions, called particles, fly through the problem space by following the current optimum particles. The detailed information will be given in following sections.

Compared to GA, the advantages of PSO are that PSO is easy to implement and there are few parameters to adjust. PSO has been successfully applied in many areas: function optimization artificial neural network training, fuzzy system control, and other areas where GA can be applied.

THE ALGORITHM

As stated before, PSO simulates the behaviors of bird flocking. Supposes the following scenario: a group of birds are randomly searching food in an area. There is only one piece of food in the area being searched. All the birds do not know where the food is. But they know how far the food is in each iteration. So what'sthe best strategy to find the food? The effective one is to follow the bird which is nearest to the food.

PSO learned from the scenario and used it to solve the optimization problems. In PSO, each single solution is a "bird" in the search space; we call it "particle". All of particles have fitness values which are evaluated by the fitness function to be optimized; and gave velocities which direct the flying of the particles. The particles fly through the problem space by following the current optimum particles.

PSO is initialized with a group of random particles (solutions) and then searches for optima by updating generations. In every iteration, each particle is updated by following two "best" values. The first one is the best solution (fitness) it has achieved so far. (The fitness value is also stored.).The value is called pbest. Another "best" value that is tracked by the particle swarm optimizer is the best value, obtained so far by any particle in the population. This best value is a global best and called the gbest. When a particle takes part of the population as its topological neighbors, the best value is a local best and is called lbest.

After finding the two best values, the particle updates its velocity and positions with following equations.

v[]=v[]=c1*rand()*(pbest[]-present[]+c2*rand()*(gbest[]-present[]

present []=present]+v[]

where

v [] is the particle velocity, Present [] is the current particle (solution).

Pbest [] and gbest [] are defined as stated before.

Rand () is a random number between (0,1)

c1, c2 are learning factors. Usually c1=c2=2.

VI. SOLUTION METHODOLOGY

The mathematical formulation is given the line flows are taken as objective function. Whenever a fault or overload contingency occurs in the system then some lines hit their limits causing congestion in the system. The generators are re-dispatched such that the congestion in the system is elevated.

ASSUMPTIONS

The following assumptions are made so as to reduce the complexity of the presentation problem

- Bus voltage assumed to be constant at 1 p.u.
- PV buses are numbered from 1 to N-1 where N is the total no. of buses.
- Nth bus is taken as a reference bus where phase angle =0

PROBLEM FORMULATION

To determine:

Optimal scheduling of generators P_{gi} i=1, 2...NG

Objective function

Minimize line flow $\sum S_{ij}$ i=j=1,2,…nbs

Subject to:

Equality constraint:

Load angle mismatch

$\delta = 0$

Load balance equation

$P_{gi} = P_{di}$

Inequality constraint:

Line flow constraint : $g \ \ \theta \ \ -g^{max} \ \leq 0$

Limits: $P_{gi_{min}} \leq P_{gi} \leq P_{gi_{max}}$ i=1, 2……NG

Where

$\theta = [\theta_1, \theta_2, \dots \dots \dots, \theta_{N-1}]$ Represents the voltage phase angle.

g(θ) is the vector of the active power flow carried by transmission lines.

g^{max} Is the vector of the transmission line rating.

P_{gi} Is the real power generation of ith generator.

P_{gimax}, P_{gimin} are minimum and maximum generation limits.

Nbs is the number of bus.

NG number of generators.

S_{ij} line flow.

VII. RESULTS AND DISCUSSION CONTINGENCY CONDITIONS

CASE A	OVER LOADED LINES	LINE FLOW	LINE LIMITS	VIOLATION
Load at bus 14 raised by 80% from base case loadings with line 1 – 2 out	1 – 3 3 – 4	153.077 141.094	130 130	34.171
Load at bus 19 raised by 55% from base case loadings with line 1 – 2 out	1– 3 3 – 4	153.567 141.522	130 130	35.089

RESULT AFTER SCHEDULING

CASE A	OVER LOADE D LINES	LINE FLOW	LINEFLOW AFTER RESCHEDU LING	VIOL ATIO N
Load at bus 14 raised by 80% from base case loadings with line 1 – 2 out	1 – 3 3 – 4	153.077 141.094	130 130	NIL
Load at bus 19 raised by 55% from base case loadings with line 1 – 2 out	1– 3 3 – 4	153.567 141.522	129.41 120.27	NIL

CASE B	OVER LOADE D LINES	LINE FLOW	LINE LIMI TS	VIOL ATIO N
load at bus 14 raised by 80% from base case loadings	1 – 3 3 – 4	146.9 135.764	130 130	22.66 4

CASE B	OVER LOADE D LINES	LINE FLOW	LINEFLOW AFTER RESCHEDU LING	VIOL ATIO N
load at bus 14 raised by 80% from base case loadings with line 1 – 2 out	1 – 3 3 – 4	146.9 135.764	129.45 120.30	NIL

GENERATOR RESCHEDULED VALUES

CASE A(1)	CASE A(2)	CASE B
Overloaded lines=0	Overloaded lines=0	Overloaded lines=0
Generator reschedule G1= 61.8019 G2= 31.4515 G3= 35.2538 G4= 24.9058 G5= 17.9127 G6= 35.2879	Generator reschedule G1= 54.3771 G2= 33.6175 G3= 38.0149 G4= 20.6371 G5= 21.7172 G6= 34.456	Generator reschedule G1= 59.377 G2= 31.317 G3= 37.014 G4= 18.637 G5= 19.717 G6= 28.148

are first evaluated and the local best termed as best is updated for all particles and then the local best termed as best is updated. This process is continued until the global best is achieved. The global best gives the generator rescheduled and thus the load flow is performed and the line limit violations are identified to be within the thermal limits. Thus the generators are rescheduled for the contingency condition and the outputs are verified.

VIII. CONCLUTION

The base case load flow is performed and the line flows are identified as within the limits. A contingency condition whit overloading and outage of line is created and the load flow analysis is performed and the overloaded lines are identified and this result are shown. The data's are loaded to the optimization problem as given and the particle swarm optimization technique which uses the generators as population and

IX. REFERENCES

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