COMPUTATIONAL FRAMEWORK FOR POWER ECONOMIC DISPATCH USING GENETIC ALGORITHM

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Abstract: Economic Dispatch Problem (EDP) is the important step in Power System operation and is non-convex optimization problem. It has been solved comprehensively with mathematical programming approaches. However, these approaches handle non-convexity with assumption and resulting in an inaccurate dispatch. Genetic algorithms are potential tools for Economic dispatch solution. Computational framework "PED_Frame" has been developed which can handle economic dispatch solutions based on mathematical programming and Genetic Algorithm based approaches independently and in hybrid form. It has been tested on standard three machine and twenty machine test systems.

1 INTRODUCTION

Power Economic Dispatch (ED) is one of the main functions of modem Energy Management System (EMS) and vital step in power system operational planning. It is defined as the process of allocating generation levels to the generating units in the mix, so that the system load may be supplied entirely and most economically (Happ, 1977). It is on-line function, carried out after every 15-30 minutes or on request in Power Control Centers.

Economic dispatch is constrained non-convex optimization problem. The cost functions of multi-valve thermal machines are non-smooth discontinuous and non-differentiable. However, the generator fuel costs are generally approximated in the continuously differentiable quadratic form while solving economic dispatch problem in mathematical programming approaches. Consequently, inaccurate dispatch results. Genetic algorithms (GA) have been used to solve the economic dispatch problem independently and in conjunction with other AI tools and optimization approaches. GA based approaches have the ability to handle the non-convex economic dispatch problem efficiently (Chao-Lung Chiang, 2005) without any restriction on objective function thus providing potential tool for real economic dispatch problem.

The concept of power market has brought the changes in the trend of power industry. The role and structure of control center is being redefined. Quick decision-making and fast answers are very significant in market environment. Flexible and extensible framework having the ability to incorporate approaches for Economic Dispatch solution may be useful tool for industry and academia.

In this paper effort has been made to develop the framework PED_Frame for economic Dispatch using Genetic Algorithm and mathematical

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programming approaches. The paper is organized as follows: Section II gives the definition of Economic dispatch problem. Section III covers concepts and architecture of PED_Frame. Section IV includes the implementation detail in PED_Frame. Lastly there is conclusion.

2 ECONMIC DISPATCH PROBLEM

The Economic Dispatch in its simplest form is formulated as:
Minimize

$$C_T = \sum_{i=1}^{N} C_i(P_i) \qquad (1)$$

Subject to equality constraint:

$$P_D + P_L = \sum_{i=1}^{N} P_i \qquad (2)$$

Inequality constraints:

$$P_{i\,(min)} \le P_i \le P_{i\,(max)} \qquad (3)$$

Where: C_T Total cost, C_i generator fuel cost of the ith generating unit, P_D total load, $P_{i(min)}$ the minimum generation power, $P_{i\,(max)}$ the maximum generation power, and P_L transmission loss given by

$$P_L = \sum_i \sum_j P_i a_{ij} P_j$$

Where: a_{ij}: transmission loss coefficient.

3 PROPOSED FRAMEWORK - "PED_Frame"

Framework is a set of cooperating classes that makeup reusable design for a specific class of software and defines overall structure of application, it's partitioning in classes and objects (Gamma, 1995). A framework can be customized to a particular application by creating application specific subclasses of abstract classes targeting a specific group of applications, which have similar architecture design. A fairly large number of useful frameworks are available for application builders. One of these frameworks is Microsoft's Document-View architecture.

The proposed framework "PED_Frame" targets power economic dispatch software application development. It provides white-box reuse mechanism for incorporating new algorithms. All inputs and outputs are handled through a grid. PED_Frame provides extremely efficient component for status visualization.

Standard Template Library (STL) is used as base for the development of the vector-matrix library. This library gives efficient algorithm implementation for vectors and matrices. Document-View Architecture acts as container for PED_Frame and provides base services. These are primarily in the form of messaging mechanisms, and threading support. The class diagram of PED_Frame is shown in figure 1.

3.1 Input/Output Using Grid

CPEDGrid class acts as interface for grid, which provides functionality like input, formatted output, print and data validation checks. It extends grid functionality to link its services with other parts of the PED_Frame. These are:

a. Data present in Grid is transferred to a matrix, which can act as data communicator.
b. Data present in matrix is formatted in grid for display and printing purposes.
c. Data editing and data validation checks.

PED_Frame creates three instances for grid class -- Machine data, B-Coefficients and output.

3.2 Analysis Status Visualization

Analysis status visualization is implemented in class CPEDAnalysisStatus derived from CDialog class of MFC. This dialog window contains progress indicators showing current state of convergence, iteration count, and time elapsed.

3.3 Analysis

This part of the framework is responsible for actual implementation of algorithm. The analysis is accomplished through following classes:

a. CPEDAnalysisBase class is derived from CWinThread so acting as independent thread of execution. It contains references to matrices for input, B-Coefficient and output, Machines count, maximum iterations count, power demand and error tolerance. It also provides virtual functions for start analysis, communicating status information and formatting output.
b. CPEDGABased is derived from CPEDAnalysisBase and works as base for implementation of genetic algorithm. This class contains information for Genetic Algorithm (GA) parameters. A new class can be derived

from this class to implement any GA based solution for Economic dispatch.

c. CPEDCABase is also derived from CPEDAnalysisBase and works as base for conventional algorithm implementation. It contains information like initial start and step length. A new class can also be derived from this class to implement any mathematical programming based solution for Economic dispatch.

3.4 Vector-Matrix Library

This library includes template based CPEDVector and CPEDMatrix classes. CPEDVector is derived from vector<class T> and it implements functionality for initialization, resizing, addition, multiplication, searching, sorting and debugging routines.

CPEDMatrix class is derived from CPEDVector < CPEDVector <calss T> > and it implements functionality for initialization, resizing, and matrix algebra operations.

3.5 MFC Document-View Architecture

PEDFramework is primarily based upon doc-view architecture of MFC. CPEDApp is derived from CWinApp, CMainFrame is derived from CFrameWnd, CPEDView is derived from CScrollView and CPEDDoc is derived from CDocument class. CPEDView contains grid objects and manages their functionality. CPEDDoc contains instances of matrix class for input matrix, B-Coefficient matrix and output matrix. The reference of these matrices is passed to respective CPEDAnaslysisBase derived class, which performs analysis by using these matrices and updates output matrix.

4 IMPLEMENTATION USING PED_FRAME

4.1 Economic Dispatch using Mathematical Programming based Approach

It can be implemented as follows:

a. Derive a class from "CPEDCABase"and declare algorithm specific parameters in it.
b. Write code for new algorithm in StartAnalyse function, which is in overridden form.
c. Call UpdateStatus with error value and current iteration.
d. Override "FormatResults" to transfer results from analysis structure to output matrix.
e. Create a new menu item and write its message handler in CPEDDoc. Create an object of Derived class and set parameters.
f. Create an object of CPEDAnalysisStatus and pass this object to it; calling its DoModal(). This will start analysis.
g. On completion of analysis just call "UpdateAllViews", this will update grid control with results.

4.2 Economic Dispatch using GA

a. Derive a class from "CPEDGABase".
b. Remaining steps are same as those in Conventional Approach.

4.3 Economic Dispatch in PED_Frame

In PED_frame following algorithms have been implemented**:**
Lamda iteration algorithm with and without loss, Simple Genetic Algorithm with typical reproduction, crossover and mutation operators, and Sequential hybrid approach, which after fixed number of generation, passes control to Lambda iteration algorithm.

The transmission loss has been calculated using B-Coefficients. The inputs are standard machine cost curves, B-coefficients, power demand. Genetic algorithm solution involves GA parameter settings. The software has been tested on 3 and 20 machine systems (Ching-Tzong Su, 2000) and several other standard test systems. However, in the paper three machine system results have been given in Table 1.

Table 1: Computational Results Using PED_Frame.

Unit Out put (MW)	Lambda Iteration	Genetic Algorithm	Hybrid
P_1	73.6600	50.0000	73.6600
P_2	69.9850	75.7173	69.9850
P_3	75.1803	93.0189	75.1803
P_{total}	218.8253	218.7362	218.8253
P_L (MW)	8.8254	8.7362	8.8254
P_D	210.0	210	210.0
Generation Cost ($/h)	3164.5664	3155.0181	3164.5664

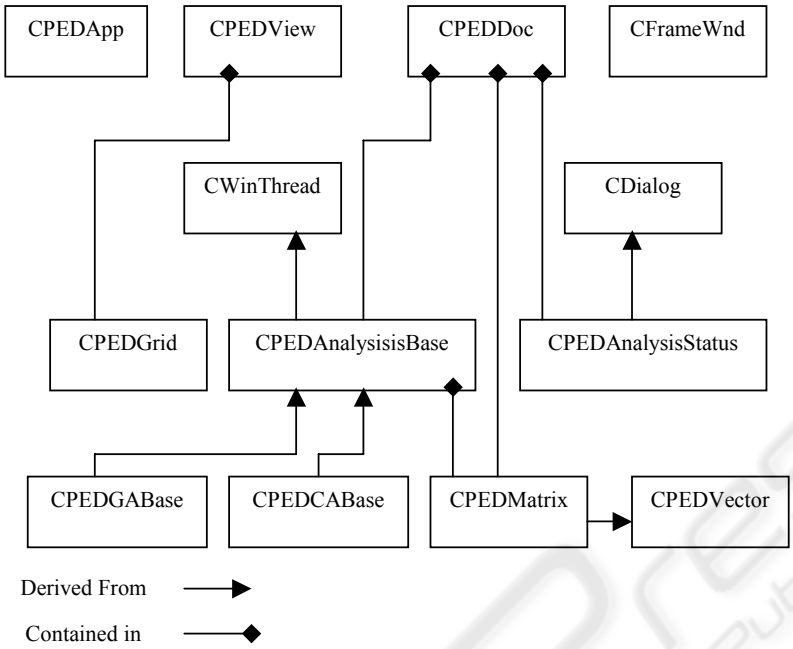

Figure 1: Class Diagram for PED_Frame.

5 CONCLUSIONS

Economic dispatch is online function and vital step in power system operational planning. It forms an important part of energy management system. It has been solved comprehensively in mathematical programming environment by approximating cost curves. However, genetic algorithm based approaches ca handle actual non-convex cost curves effectively. In this paper a framework has been developed which can handle economic dispatch using classical optimization and Genetic Algorithm based approaches independently and in hybrid form. It has been tested for on 3 machine, 20 machine systems and several other standard test systems. It is the platform, which is flexible, extensible and useful for many individuals. Step by step transition of PED_Frame to the computational framework "Power System Master (PSM)" would be the future activities to achieve the goal of developing the software package for Power System Operational Planning.

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