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The decomposition and computation method for distributed optimal power flow based on message passing interface (MPI)

Keyan Liu [a], Yunhua Li [a,*], Wanxing Sheng [b]

[a] School of Auto. Sci. and Electric. Eng., Beijing University of Aeronautics and Astronautics, Beijing 100191, PR China
[b] China Electric Power Research Institute, Beijing, PR China

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ABSTRACT

This paper investigates the decomposition and computation method for the distributed optimal power flow (DOPF) based on message passing interface (MPI) framework in large-scale interconnected power grids. Firstly, a DC-DOPF model and an AC-DOPF model are introduced respectively. Next, a new equivalent decomposition model to be used to solve DC-DOPF and AC-DOPF is proposed. It decomposes the OPF computation of large power grid into the sub-problems of interconnected multiple regions. Then, two different decomposition methods, i.e., partial duality and auxiliary problem principle (APP), are used to solve interconnected DC-DOPF and AC-DOPF, respectively. DC-DOPF and AC-DOPF are modeled as multiple base-cases OPF to get the runtime status in real time. Finally, several experiments are implemented based on multiple interconnected IEEE RTS-96 regions and IEEE 118 test regions. The computational results illustrate that the proposed decomposition and computation methods for DOPF based on MPI are applicable and effective, and it can be as a useful computation method for interconnected power system.

1. Introduction

It is necessary for large-scale interconnected power grid to coordinate with each other so as to guarantee the reliability and the economical dispatch of the grid, although each region has its own independent system operator (ISO) under the electric power market environment. In order to realize the optimal disposition of the wider range resources, and to carry on the competition in a larger market, the power exchange among the network interconnections is becoming more frequent. To maximize social wealth, interconnected transmission grid system is becoming a trend. For example, electrical power system in China experienced a rapid development and large region power grid has begun to be interconnected in the past several years.

OPF is an efficient tool to solve the operation problem and planning problem. How to get an optimal feasible solution is a challenge issue in the OPF of interconnected grid system. The requirement for faster and more frequent solutions has encouraged the consideration of distributed parallel implementations. Distributed computing environments can greatly increase the available computing capacity, with faster OPF solutions and low hardware cost. High performance computation is also necessary for real time control and scheduling of an interconnected power system.

Parallel processing, a method that solves one large problem by using many small tasks, has emerged during the last decade as a key technology in modern computing science. With the increasing availability of hardware and software, distributed parallel computation has been used in various fields. Unlike traditional approaches of OPF, distributed computing in this paper decomposes overall OPF problem into small OPF sub-problem of regions. Taking the advantage that coupling constraints can be decomposed, the optimization performance can be improved in many mathematical and scientific computation [1]. A solution of large problem can be decomposed and solved using the distributed computation resources.

The basic idea to optimize the large system is to decompose the overall problem into a series of sub-problems and then to optimize every sub-problem independently. The method is to decompose the original problem to several independent sub-problems to reduce step number that the problem solves, and to obtain the overall optimal solution. The common mathematical methods to decomposition can be categorized as: the Benders decomposition, the Dantzig–Wolfe decomposition and Lagrange relaxation decomposition. In this paper, based on the partial duality [2] and auxiliary problem principle (APP) (based on Lagrange relaxation) [3], the overall DC-DOPF and AC-DOPF solution problem are decomposed into on-line coordination optimization solutions of multiple regions.

Parallel computing has emerged as a big trend in recent years. Multi-core is becoming commoditized very quickly – dual core

* Corresponding author. Tel./fax: +86 10 82339038.
E-mail address: yhli@buaa.edu.cn (Y. Li).

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