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Integrating GRID Computing Technology in Modifing Modern Power System

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Abstract
With the need for ever increasing reliable, powerful, and clean power generation in power systems is becoming a major challenge, particularly against cascading failures that lead to blackouts. As a result power systems have become more complicated, the operation and control of the power system is actually becoming a huge data-intensive, information-intensive, communication-intensive and computing-intensive application. The philosophy of grid computing play an important role in power system distributed monitoring, control and distributed parallel computing. Grid computing can provide services in power generation, transmission distribution and in its marketing [1]. A review is presented on the research which has been carried out in the last few years in this area regarding the applicability of grid computing technology in modern power system reliability and security analysis, operations, monitoring and control systems.

Keywords
Electrical power system, Grid computing, Software Architecture, Monitoring and Control, Reliability and Security, Load Scheduling and Balancing

I. Introduction
Power networks are interconnected to form a large-scale power system in an attempt to enhance the reliability and stability. The large-scale interconnected and inherently distributed power system raises higher requirements in communication infrastructure, control technology, operation strategy and the capability to prevent catastrophic failure [2]. As modern power systems rely more heavily on computerized communications and control, data storage capacity and network performance. Modern applications are demanding more and more computational power which cannot be satisfied by the existing individual computers. In order to meet these computational challenges, it is necessary to have a standardized means of connecting disparate resources over high speed networks to build high power virtual supercomputers [3]. The application of grid computing into smart electrical utility as a new computing generation that uses the resources of many separated computers connected by a network for solving such massive computation problems by making use of the underutilized resources or grid shared resources. Grid computing shares the heterogeneous resources (based on different platforms (operating systems), hardware/software architectures, and computer languages, located in different locations depending on Grid systems architecture using open standards and protocols [4].

II. Grid Computing: A Brief Overview
Grid computing is a new technology that involves the integrated and collaborative use of computers, networks, databases and scientific instruments owned and managed by multiple organisations [1]. It is able to provide HPC and access to remote, heterogeneous and geographically separated vast area. Grid computing, like internet provides sharing of computational power and resources such as data storage, databases, and hardware and software architectures, as shown in fig. 1.

In past few years, this technology has gained much attention from power engineering field and significant research is being done at different places in order to investigate the potential use of grid computing technology and in order to applying this technology in power engineering field [5, 10–13].Grid computing is a form of parallel and distributed computing that involves coordination and sharing of computing, application, data storage and network resources across dynamic and geographically distributed organisations[6].

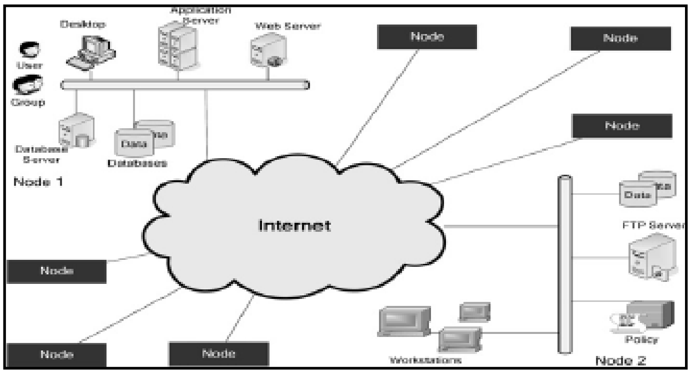

Fig. 1: Grid Computing Architecture

Modern electrical grids are computer enabled power networks that provide efficient and smooth management, monitoring and information exchange of distributed power networks with diverse widespread resources of power generation [7]. The electrical grid in near future will be transformed from existing centralized generation to collaborative networks that will incorporate customer appliances and equipments and modern information devices in the distribution. The advantages and features of grid computing are:

- Parallel processing
- Load balancing and task scheduling
- Reliability of computing grids
- Security
- Efficient use of idle resources

III. Review on the Application of Software Architecture in Power System
As modern power systems rely more heavily on computerized communications and control, operation and control of a power system. Hence the system security has become increasingly dependent on protecting the integrity of the associated information systems. In order to deal with the operation and control of large-scale interconnected power network, many infrastructures have been proposed [8-10].

A. Proposed System Structure

The author in [11] first initiates the use of grid computing in electric power system. The potential benefits of grid computing for future power system are described, including monitoring and control, market entry and participation, regulation and planning. The Research Centre for Electric Power System Automation (RCEPSA) at UESTC is conducting research on application of grid computing in electric power system and developed a grid computing platform for electric power system----PSGrid® (Power System Grid). The management and the coordination of the computing resource in the pool are achieved by grid computing.

Fig. 2, is the proposed infrastructure for the power system operation, control and computing. The interconnected power network is generally a geographically dispersed system, and is partitioned into different areas. The power grids in different area are connected with tie lines. In modern power system, every area has an ISO to manage the control and operation of its power network and power market. And there is generally a supervisory board to coordinate among the group of ISO's.

The PSGrid® is designed to perform grid computing in the power network. Nowadays, most power equipments are generally equipped with a grid computing technology for data acquisition or data communication purposes. This technology now-a-days play a vital role in advancement of modifying modern power system in generation, transmission, and distribution of power.

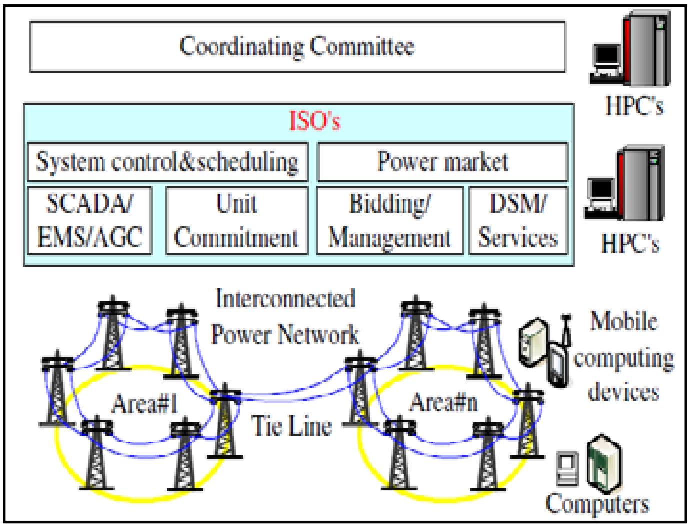

Fig. 2: Proposed Infrastructure of PSGrid®

B. System Implementation

A platform (PSGrid®) is proposed for implementation of distributed monitoring and control and distributed parallel computing in literature [9]. In this section, agent technology is used for performance improvement of the system only based on grid computing technology. A distributed monitoring and control system only based on grid computing is shown in Fig. 3. This system permits parallel request to distributed data through using the virtual database technology. An improved system with agent technology is shown in fig. 4.

In the system, the different data drivers are integrated into the data access agent, which can provide access to heterogeneous data sources and package in specific format for the request initiator. The monitoring control agent is responsible the data collection at local site and execute the orders from the control centre. The data mining and other specific application are also integrated into an agent.

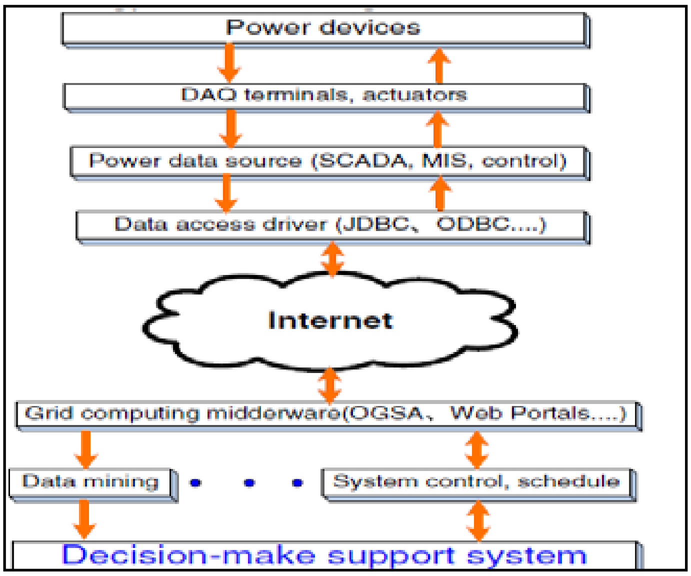

Fig. 3: Structure of Distributed Power System Monitoring and Control System Based on the Grid Computing

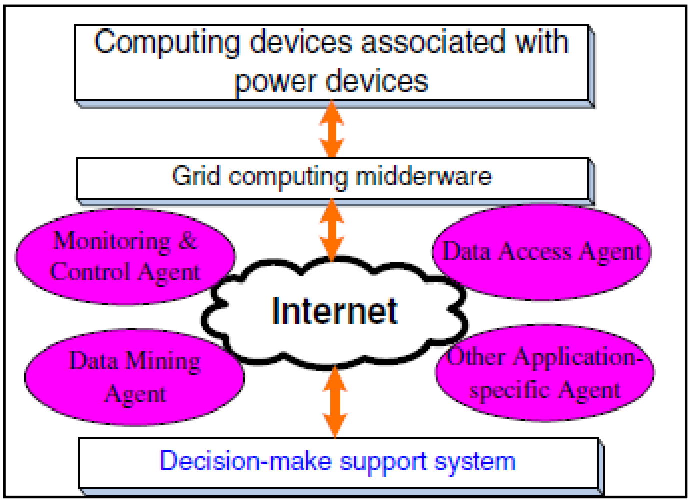

Fig. 4: Structure of Distributed Power System Monitoring and Control System Based on the Agent and Grid Computing

The proposed scheme is applied in the lab test bench as shown in fig. 5. Four regular computers are assigned as the computing nodes, and a high performance computer is assigned as the server. These computers are located together in a lab and interconnected through LAN.

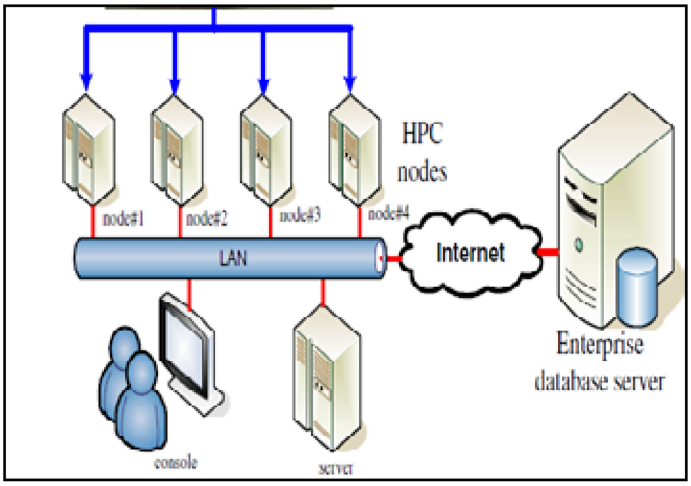

Fig. 5: Lab Test Bench

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The 4 computing nodes are equipped with data acquisition & control devices to simulate the SCADA in real power system. With this scheme, the system is much more stable. When a computing node is at fault condition, the agent can inform the server at the request side in advance, hence avoiding wasting time on fault nodes.

IV. Potential Benefits of Grid Computing in Modifying Modern Power System

A. Modern Power System Operation

The modern power system operations involves the secure operation of the power system depends on the control strategies and the monitored data. These functions are achieved by Energy Management System (EMS), including SCADA (Supervisory Control And Data Analysis) to perform data acquisition, alerting, monitoring and control, Automatic Generation Control (AGC), to guarantee that the power system is always operating at the normal state, economic Dispatch And Control (EDC) system to realize the optimal operation of the power system, and security assessment (SA) to guarantee the stability and security of the power system as shown in fig. 6.

These operations are geographically distributed, independent and autonomous. And these operations have similarity and repetition, and they require coordination with each other. The coordination and cooperation among relatively independent entities in a large geographically distributed area requires high-performance robust software architecture.

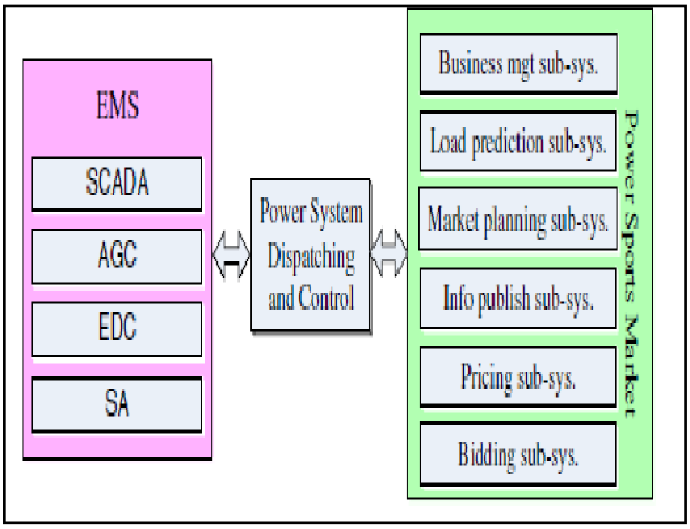

Fig. 6: Operation Scenario in Modern Power System

B. Monitoring & Control

It is anticipated that a large number of smaller generators will be introduced in the coming decades [11]. As these generators are connected into the power system (often embedded at the distribution level), it will become necessary to monitor and control their output level and their on/off schedule. The control technology in use at the transmission level is not scalable to very large numbers of generators. Grid computing can provide a relatively inexpensive new technology allowing the output of embedded generators to be monitored and, when necessary, controlled. An outline of a power-systems grid-computing structure is illustrated in fig. 7.

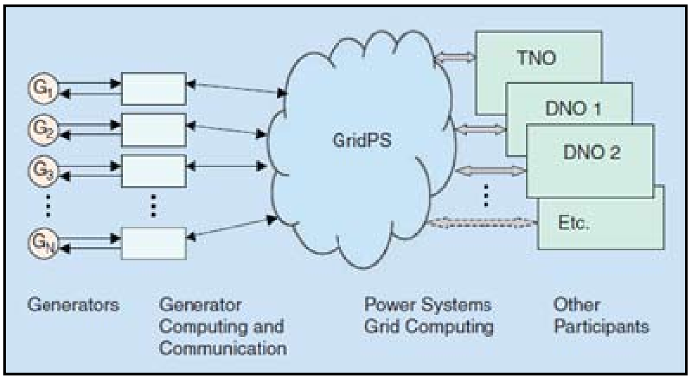

Fig. 7: Power System Grid Computing

C. Electricity Market

With the deregulation in the power systems, competitive electricity markets are formed in many parts of the world which also has an important function. The Open Access Same-time Information System (OASIS) has already been implemented in USA through which small organization even the individuals can take part in electricity trading [12]. For this all companies need to be registered in-order to share their information and to know the market strength. A grid computing approach for forecasting electricity market prices based on a neural network time-series model [13] in order to improve the computational speed and accuracy of the forecasting using existing application programs has been designed for a single computer processing.

D. Power System Regulation

Regulation is consistently under review to ensure efficiency and competitiveness of the electricity market as well as maintaining reliable energy supply to customers. Grid computing has capability to work in both regulated and deregulated environment with different types of access to the information. Grid computing can provide the environment of electricity market in the form of virtual organisation.

E. Power System Reliability and Security Analysis

A grid computing framework for power system reliability and security analysis of large and complex systems has been proposed in [14] for power system reliability and security analysis. for probabilistic load flow analysis, Monte Carlo simulation (MCS) is used as an undemanding technique for probabilistic small signal stability analysis in electric power systems. As compared to traditional computing techniques, the gird computing has given better performances for PSSS (power system small signal stability analysis) in terms of computing capacity, speed, accuracy and stability.

F. Power System Planning

Planning needs analysis of large amount of data, which requires simulation and modelling. A key source is required for successful simulation and modelling and Grid computing provides the power for this purpose. Planning of future power systems needs the combine effort of many companies [11]. The sharing of accurate and reliable information and forecasting mechanism facilitate this process. Grid computing provides an integrated environment for this purpose for all the companies and individuals involving in planning for power systems.

G. Power System Scheduling, Load Balancing and Available Transfer Capability

Energy storage is one of the major problems with electricity as a service. For this reason, there is always need to generate energy according to demand load. Grid computing can provide the services to minimise the difference between the generation and demand load as much as possible by using the load-balancing services. A grid computing architecture has been designed for reactive power optimisation [15], which is an important measure to improve the voltage profiles and helps in reducing the real power losses by scheduling the reactive power resources.

Moreover, a grid computing-based application has been developed for load balancing for distributed and integrated power generation systems [16]. This application can perform real-time load-forecasting and load-balancing operations over decentralised energy resources.

V. Conclusion and Further Research

Grid Computing as a new distributing computing technology can group all the resource as a virtual computer resource pool and handle geographically distributed system. Because of these characteristics of Grid Computing, it could be the best tool required along with future development in electrical power system by supporting trading activities, power marketing decision analysing, power system controlling.

This paper highlights the advantages and huge potentials of grid computing applications in power engineering. Some organisations have started practicing this technology in power industry; however, still plenty of research can be done in various fields in obtaining full advantage of this technology in enhancing efficiency of electricity market, more accurate and efficient analysis, and distributed monitoring and control mechanisms especially in the presence of renewable energy resources.

There is plenty of room available for conducting research in power system regulation, which can differ from organisation to organisation and market to market.

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