Developing Power Systems Reliability and Efficiency by Integrating Grid Computing Technology

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Abstract: - The need for reliable, redundant, and clean power generation in power systems is becoming more importance. This need requires geographically-distributed power systems to be integrated as a single entity where among the main features of this integration are large data base and computing intensive. Hence the current power systems are not able to handle this huge datasets required for that integration, Grid Computing is a gateway to virtual storage media and processing power. This paper analyzes, describes and simulates the integration of modern power systems into grid computing technology. Paper begins by introducing grid computing as a technology, defining selected middleware. Two power implementations are illustrated, power load forecasting within traditional and grid computing based systems, and real time power system controlling and monitoring with grid computing technology integration to enhance power system reliability. Developed reliable backup system strategy has been achieved by implementing grid computing technology as an innovative integration benefit.

Key-Words: - Computational grid, idle resource, grid computing, resource broker, job, node, grid middleware.

1 Introduction

Modern power systems consist of a large number of small-scale, highly dispersed generation units of variance energy sources. These systems are connected in a specific way that allows information exchange, monitoring and control. Grid computing leverages idle/available resources of networked computers to increase overall computational performance. This grid mechanism provides faster, cheaper, efficient and more powerful computational performance comparable to the performance of super computers.

Modern power systems and electrical energy applications are demanding more and more computational power, which cannot be achieved by the existing computing technology or 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 [4] and the methodology to compute these computational processes with efficient and high quality of services. Computational power refers to processor processing speed, data storage capacity and network performance. 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 [5]. The electrical grid will be transformed from central generation down to collaborative networks that will incorporate customer appliances and equipment and modern information devices in the distribution. The future electrical grids will consist of large small-scale generation units of renewable energy sources and other disparate energy sources. Highly scalable and decentralized integrated communication, computing and power networks will be necessary to monitor these smart grids of the future [3].

Automation in the electrical engineering has a long tradition and is closely connected with used system architecture. After the first use of process computers at the end of the 60s and respectively at the beginning of the 70s, client/server architectures were established in the 80s, and these are still dominant today. With the rise of the Internet in the private as well as in the business sector the used structure was adjusted. But in recent years, instrumentation and controlling systems were introduced, where the architecture of the Internet was already being considered during the development phase. In this case the system is known as the fourth generation.

2 Computational and Power Grid

From the basic understanding of power electrical grid that whenever any kind of generator is connected to the grid, means this generator is ready to feed the grid with the required or demanded power. This system is working in a dynamic mode that generators are joining and leaving the grid in a specific scheduling and mechanism.

In the same how, grid computing came analogy following the same scenario that in the computational grid any computing resource once connected to the grid (grid computing network) is ready to support the computational grid with demanded computing power or storage facility.

3 GRID COMPUTING (GC)

Grid computing is a powerful and efficient computational technology which represented as an advanced step for the previous distributing computing. Along with the high network communication speed and high technical specified machines (PC, Desktops, super computers...) distributed computing still suffering from some limitations because of the way and the percentage of using these resources (power gaining)[6,7].

Grid computing 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 [8].

Grid computing is solving such large scale of problems which could not be solved within the traditional computing methods due to the limited memory, or computing power. Grid system required a high speed network working under specific or specialized software called grid middleware [6,7,9], which allows the distributed resources to work together in a relatively smooth and transparent manner.

Using or getting benefit from idle computer's lost power make Grid distributed computing work much faster with high accuracy, lead to more progress and increase development curve.

Traditional monitoring and control that is employed in the current electrical grids is highly centralized and not scalable to include new distributed and embedded renewable energy sources [3]. Grid computing technology provides a computational model / infrastructure to solve massive computational problem involved in smart electrical grid operation. This monitoring and control of the future power systems will be both highly scalable and universally adoptable because of its distributed nature and use of open standards. The application of grid computing helps solve problems that may be too large for the single supercomputer but at the same time retains the flexibility to work on distributed smaller problems [1]. The smart electrical grid will integrate old technologies with new technologies such as superconductors, energy storage, and customer load management. Application of suitable Information Technologies such as grid computing will enable active and collaborative participation of consumers, utilities and third parties in energy markets. This will be the key to stabilization of prices [1].

The following additional benefits achieved through implementation of smart grid into grid computing

- Enhancement of energy security
- Reduction of single point of failure / vulnerability due to the distributed network based electric system.
- Stable “self healing networks” through the incorporation of automatic system reconfiguration in response to disruptions
- Reduction of computational costs through utilization of idle computer resources
- Real time information flow across the grid maximizes productivity and efficiency and minimizes the need for inventory
- Small distributed power generators can increase reliability up to 99.999999% as compared to modern grid of about 99.99%. This high quality power is highly desirable in hospitals, data centers and high-tech plants [6].
- Environmental benefits by use of clean and renewable energy sources.
- Increased integration of distributed generation which leads to reduced forced outages and reduction in blackout probability

Computational grids were developed as an answer to increased computational resource demands of science. Higher computing throughput is achieved by taking advantage of many networked computers to model a virtual computer architecture that can distribute thread or process execution across a parallel infrastructure [1]. Grid computing thus enables research on large scale data and resource- intensive applications that require more computing power than what a single supercomputer or single-domain cluster can provide [8]. A fully functional computer grid prototype can be traced back to the early 1970's at the University of California, Irvine's Distributed Computing System. However, this early prototype did not go far because of the complexity of security and administrative issues involved at the time. Though this is still a problem in the modern grids, the security issues have been fairly well managed. Ian Foster, Carl Kesselman and Steve Tuecke are referred to as the 'fathers of the grid' due to their pioneering ideas in the modern day grid that led to the development of Globus Toolkit which incorporated CPU management (such as cluster management and cycle scavenging), storage management, security infrastructure, data movement, monitoring and other additional grid services [1].

Summary of the factors that led to the emergence of computational grids

- Availability of faster PCs and workstations
- Availability of high-speed networks or gigabit Ethernets
- Need to solve large scale computational problems

4 GC ARCHITECTURE

For any grid computing system there are various layers present. They are fabric layer, Middleware and the application layer. as shown in Figure 2.

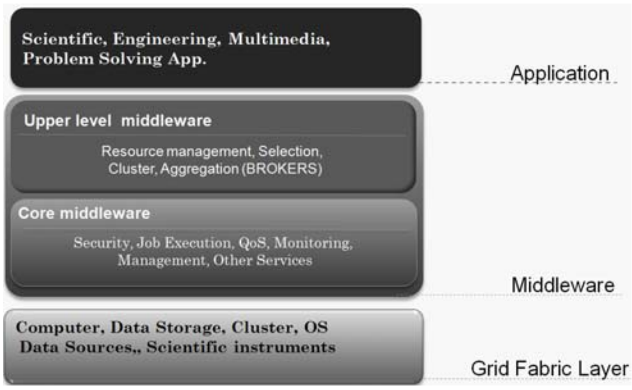

Figure 1: Grid Computing Architecture

Grid Fabric layer: This the base layer which contains the distributed resources like computer, clusters, data storage, data resources and other scientific instruments and sensors. There can also be some super computers among the resources. All the computers may have different operating systems; they are not restricted to only one OS.

Middleware*:* They are of two types. They are core-middleware and upper level or user level middleware. Both of them have different services.

Core middleware: There are many services provided in this layer such as security, job execution, information registry and services, remote process management and some services of QoS (Quality of Services). Example can be Globus or SGE (Sun Grid Engine) toolkit middleware.

Upper-level middleware: They provide services in addition to the services provided by the core middleware. Some of them are application development, programming tools and resource broker. The important one in this layer is the resource broker which helps in submitting, scheduling the jobs.

Application layer: Many applications can be constructed on top of these layers described. The applications may be from engineering field, science or multimedia which has computational intensive or data intensive problems.

In addition, for grid computing systems there are some aspects which have to be considered, such like:

- Software and hardware integration of the available resources
- The deployment of low-level middleware to give secure access to the resources and upper level middleware for the application development
- To develop an appropriate application to use the resources

4.1. Grid Middleware

Grid Toolkit is represented as one of the most important elements which characterizes grid network computational efficiency, and in the same time limits the compatibility for applying specific applications. Many companies and developers are offering variant Grid Computing middleware, which have different facilities, capacities, and capabilities to achieve wide range of electrical engineering applications. Due to the high sensitivity and complexity, electrical energy systems are demanding proficient and reliable GC solutions (middleware).

Any Grid Computing system structure is consisting of three major elements for processing Grid jobs: The submitter (manager), which, apply the job to the Grid network and monitor them, the broker which, detect, and control computational process, and one or more contributor(s) to Process the job and data storing.

5 GC and Power Engineering

Grid Computing is now seen as a powerful and important tool for the electrical engineering applications. These days the power system operation and control involves large data-intensive, time-intensive applications. Therefore it can get a better solution by using this new technology. Also the power system is moving towards the renewable energy sources. In this case it helps them in providing cheap and efficient electrical energy supply.

The demand for conservation of the current conventional energy has been increased due to the growing concern on the deteriorating condition of our environment. [1]

The control and operations of modern power systems are becoming data-intensive, information-intensive, communication-intensive and computation-intensive due to much of the reliance of these power systems on computerized communications and control. [11]

Therefore, since Grid Computing is considered as an inexpensive means for "super-computing" for dealing with heterogeneous and distributed computing [7], Grid Computing is the best option in providing the necessary storage media for the huge data, intensive computational processes and also the required computing resources.

In the same time electrical energy engineering is looking to the future vision of electrical power systems which has to be more stable, more accurate power load and market forecasting, better power generation scheduling, and real time weather forecasting. All these parameters are playing the major role in shaping current and future electrical energy and the best way for engineering them. On the other hand time, cost and reliability are considered as the key control for all mentioned parameters. Therefore, GC technology comes as a best solution which offering secured, high capacity and capability within cheap ways to integrate it with electrical energy application.

6 Modern Power systems

It is estimated that by 2050, the world's electrical energy needs will be somewhere between 30 and 60 Terra Watts (TW) of electric power from the current 12 TW [12]. This kind of electric energy will require efficient and secure distributed, storage, transmission modern grid technologies in order to be delivered globally within high quality. GC technology will be necessary to provide a computational infrastructure to solve the diverse computational problems involved in future envisioned electrical grid operation. Traditional monitoring and control that is employed in the current electrical grids is highly centralized and not scalable enough to include new highly scaled, distributed and embedded renewable energy sources [3]. Monitoring and control of the future power systems will be both highly scalable and universally adoptable because of its distributed nature and use of open standards. The application of GC helps to solve problems that may be too large for the single supercomputer but at the same time retains the flexibility to work on distributed smaller problems [13].

Application of suitable Information Technologies such as GC will enable active and collaborative participation of consumers, utilities and third parties in energy markets. This will help to stabilize the prices and to be a key for shaping future power market [13].

Two instances of massive power failures have highlighted the need and the urgency to develop enveloping, intelligent and reliable smart or modern electrical grids in order to manage with the ever increasing energy demands. The 2003 large scale power failure in North America that affected many parts of US and Canada is one instance. The other more recent power failure occurred in early November, 2006 and affected many parts of Germany, France and Belgium. National or regional modern grid implementations, will allow power utilities to virtually upgrade power lines, substations and other electrical transmission equipment without huge expensive physical replacements [14].

Distributed monitoring and control of the small-scale generation units will virtually eliminate national power failures. Implementation of modern electrical grid into grid computing will achieve many benefits scaling from enhancement energy security and stability through the incorporation of automatic system reconfiguration in response to disruptions, reduction of computational costs through utilization of networked computer resources which owned and operated by others (less power consuming, less cost for buying machines, and less maintaining costs …), using the clean and renewable energy sources will reduce environmental pollution. Active customer participation enables energy conservation. Pilot projects indicate that fewer power stations would be needed than is the case now if the whole grid went intelligent or smart [3]. Future electrical grids will thus effectively reduce gas emissions and help in reducing effects of global warming and environmental degradation, some of the biggest challenges facing humanity in modern times, increased integration of distributed generation which leads to reduced forced outages and reduction in blackout probability, and reduction of a single point of failure / vulnerability due to the distributed network based electric system.

Also in the modern power systems, both power generation side and customers on the other side are reacting to other similarly that both could be in selling mode and later changing to the buying one. The new power organization behave as fully dynamic system which allow all its partners to share and exchange activities and positions. This dynamic system needs a high level of monitoring, controlling and efficiency to ensure accurate and best quality of services. From figure 1, it is illustrating the modern power system environment or organization which include all operators in one cluster due to the dependency and complimentary.

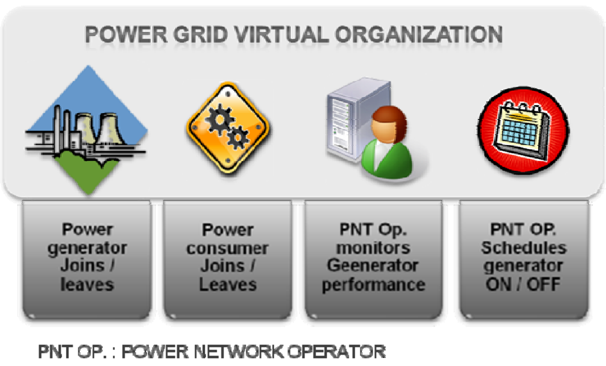

Figure 2: Power grid virtual organization

7 Power System Conversion

Modern power systems in general are changing into larger numbers of smaller-scale highly dispersed generation's units that use both current generation technologies and renewable energy sources to reduce carbon dioxide emissions [1,3]. These modern systems need to be connected into modern facilitated network to enable transferring, monitoring and controlling their situation within high speed techniques [1, 15]. GC is the technology which is capable to provide such high speed of computations within huge datasets that to be transferred among power systems. While, these generators are connected into the power system it will become necessary to analyze, monitor and control their output level and their on/off schedule. The control technology in use at transmission level is not scalable to very large numbers of generators. GC is the technology which is capable of providing a relatively inexpensive new solution, allowing the output of embedded generators to be analyzed, monitored and when necessary controlled [16].

The advantages of current powerful and high performance computers and network services facilitate and solve many of power engineering problems which may need for such a high technically specified machines and services. In the same time, along with the developments of engineering applications and technologies in general and power systems specifically, a lot of obstacles limit these developments due to two major reasons, either the machines' performance, which may not sufficient and match solutions' requirement or inefficient use of these facilities.

Looking to the modern engineering technologies, which are depending on computers' performance for solving and developing them, make these technologies to be absolutely dependent on the performance of these machines and the way of using or tapping the percentage of these machines' power.

Dealing with huge power load data make this technology always suffering from time and cost difficulties rather than others. The time required to solve any power problem and cost due to needed resources make using more powerful computing technology is the efficient solution to solve these power applications.

8 Why Grid Computing

The development of GC is also motivated by the possible benefits that can be gained by using GC within any organisation [17]. To get the reasons why GC is needed, some GC characteristics and benefits are followed:

a) Utilising Underutilised Resources
In most organisations, many computing resources are idle and underutilised at most of the times. For example, most desktop computers are idle more than 95% of their time [17]. Realising that these idle times are being wasted and not profitable to the organisation, GC provide the solution for exploiting underutilised resources.
In addition to processing resources, it is often that computing resources have also large amount of unused storage capacity. And Grid Computing allows these unused capacities to be considered as a single virtual storage media where the need of huge storage capacity within a particular application is resolved. Thus, the performance of this application is improved if compared running this application over a single computer.

b) Parallel CPU Capacity
The possibility of applying massive parallel CPU activity within an application is one of the main exciting features of GC. While the need for parallel CPU activity may initially pertaining to scientific purposes, this need is

now being extended to different fields such as financial modelling, oil exploration and motion picture animation, causing revolutionary working methodology in these fields. Though this idea of parallel CPU activity is chillingly attractive to be implemented, many barriers that exist within GC infrastructure have to be overcome before a perfect parallel CPU utilisation can be realised.

c) Resource Balancing
GC groups multiple heterogeneous resources into a single virtual resource. Furthermore, the grid also facilitates in balancing these resources depending on the requirements of the tasks. As a result, appropriate resources are selected based on the time of execution and the priority of each task. In larger organisations, unexpected peak load of activity is handled effectively by the grid and therefore ensures the smoothness of load balancing. This invaluable feature of GC is realised through the process of profiling individual resource based on its availability and capacity.

From these individual benefits, the benefits of GC as described above [18], can be categorised into:

a) Business benefits
   - Faster time to obtain the results (Faster results guide to best of manage and first in market)
   - Increase productivity
b) Technology benefits
   - Optimise existing infrastructure
   - Increase access to data and collaboration

Resilient, highly available infrastructure

- The main thing with GC is time saving since it speeds the application. Time intensive problems can be solved quickly in less time.
- Many companies and organizations can improve the speed and quality of the product.
- In order to reduce the computational time all the resources all over the world are aggregated.
- Cooperating with other organizations and sharing the resources is easy.
- There is access to remote database. Sharing of these database systems is very much important in certain application where they analyze huge data sets.
- Existing resources are utilized efficiently and effectively.
- GC provides increased and cost-effective storage.
- There is increased productivity as they provide the required resources, which are there on demand, to the users. Productivity also rises due to increase in computational activity.
- Grid resources are connected securely. Sharing of the computer resources and data are very secure. Security is important in the case of file sharing and other data sets.
- Good infrastructure for balancing the load.
- Not only computer resources are brought together but also the human resources, thus forming a virtual organization.

9 GC Challenges / Problems

Grid services transparently provide access to the entire collection of information processing system that includes computing, data and application resources. While the grid framework has seen great developments in the recent past, the greatest challenge remains the development and deployment of applications. Application development remains a great barrier due to the heterogeneous nature of the underlying resources [19]. This is illustrated by the fact that application libraries are installed differently on different machines. This makes batch jobs, scripts and executables not easily transferable from one system to another.

Grid Web services are partially trying to minimize this problem by abstracting program installation and execution from the users. Universal adoption of programs like java is also helping to minimize this portability problem.

Software compatibility is another factor that affects development of grids. Not all middleware are compatible with available toolkits. Due to this fact, proper choice of toolkits and third party middleware is very important. Successful grid task completion is only possible with correct toolkit and middleware combinations.

10 Power Systems Challenges

In a distributed and integrated power systems (PS's), it is vital to ensure that each power source (generator, wind turbine, etc) is working within its allowed parameters. These parameters are normally based on the current power load that are sometimes have been forecasted within regular intervals (weekly, monthly or yearly) [19]. Anyway, these non real-time forecasts have their drawbacks and may not supplying correct information when any of these events occurred:

1) Sudden failure of any of the power sources
2) Unexpected increase or decrease of power demand within a short timeframe

During the occurrence of any of these events, power load balancing within these power sources are required within immediate timeframe in order to ensure that there will be no power interruptions.

From this point it could be recognized that the integration of current power systems and designing modern electrical energy systems are requiring smarter and more intelligent systems to enable reaching a higher level, faster real time monitoring, controlling and scheduling for future electrical power systems.

11 Proposed Model for Integrating GC with Power Applications

The model proposed for integrating GC with power applications as illustrated in Figure 2.

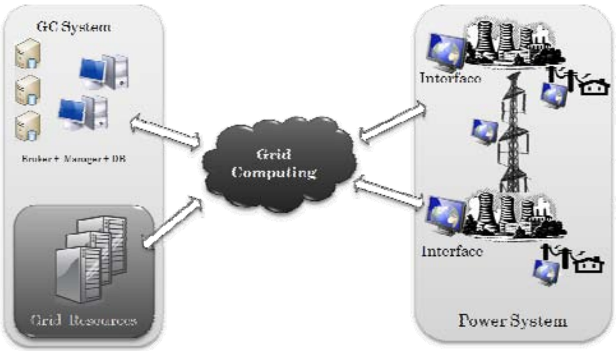

Figure 3: Grid Computing Model Integrating with Power Applications

From Figure 2, further descriptions of the model are as follows:

a) The model infrastructure is combining power systems via application interface with grid resources connected in a GC system, which share processing power and data storage.
b) The power applications interact with GC system to obtain the current list of all power applications connected to the GC and therefore, these power applications will interact with each other for real-time operations.
c) GC system broker is in charging to find available GC resources meeting certain specifications in order to perform real-time electrical energy application.

12 GC Implementation Mechanism in Electrical Energy Engineering

As illustrated in figure 2, electrical grid is a part of the computational grid and visa versa. In other words, both electrical and computational grids are acting as one system, which scientists are still trying to find the most specific name among all given ones, like smart grids, modern power systems, micro grids, virtual power grid, and VPP virtual power plant. So, for any electrical power application, computerized power systems are facilitated with the GC available resources, sharing and handling any application to enhance and speed it up. In figure 3, the architecture of applying or combining GC with electrical power systems, showing that during normal and stable power system running, GC system is sharing power system operations. [1, 2]

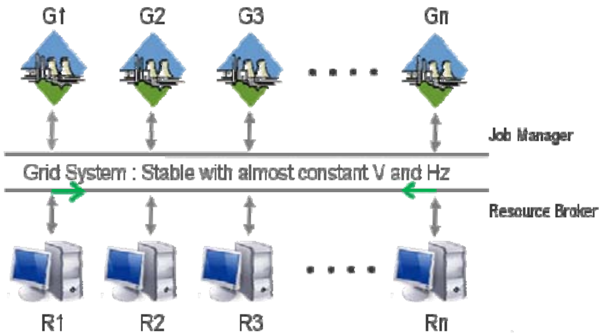

Figure 4: Integration GC into electrical power system

An example of GC application with electrical power system as illustrated in figure 4, when any fault may happen in any part of power system (power plant generator(s)), compensating lost power due to that fault needs a fast and accurate response that GC system is offering GC resources which are exchanging continuously real time power system information, then it could nominate best compensational part to react to that fault. In the same how for real time power demand which GC system can offer better power generation scheduling, load balancing and controlling due to fast, accurate, and available data or information.

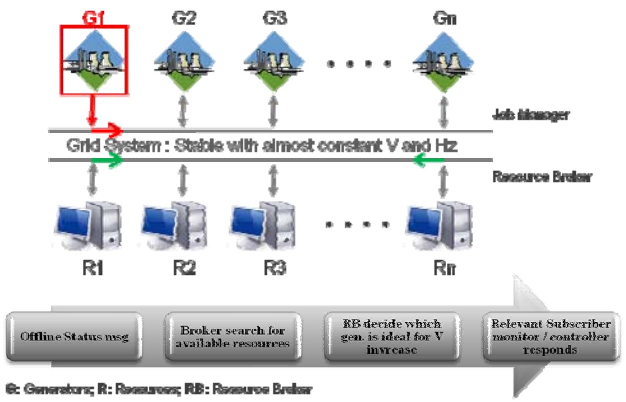

Figure 5: GC application with electrical power system

Figure 5 illustrates the GC-PS integrated system fault reaction mechanism. Status massages are to be sent frequently through the whole system (GC and PS), that all GC components (PC's, sensors, devices …etc.) are having update system information. Resource broker is managing job issues and decision making. For any failure grid computing system is reacting within most available information to composite the fault by send run job or activating existed schedule or most convenient power system.

13 Grid Power System Applications

GC applications are implemented in the South Westphalia University (SWU), where different GC tools are used; such like DeskGrid, Globus, and SGE GC systems which are applied for power systems implementation and applications. Power load forecasting, power load balancing, and power reliable backup system application and mechanism are some of these applications for analyzing the performance GC especially for a real-time data transfer and time consuming. [1, 2]

Power load forecasting computing are Implemented within both technologies traditional and grid to achieve compare and analyze new technology benefits and differences. Traditional method is implemented by using normal unique machine, then job is submitted and time is measured. The same task is submitted into grid system successfully. Time comparison shows that grid system consumed much less time with high efficiency and high accuracy. From figure 5, it is clear that traditional method consumed 260 minutes (red bar) while grid computational process needed 75 minutes to achieve same job (blue bar).

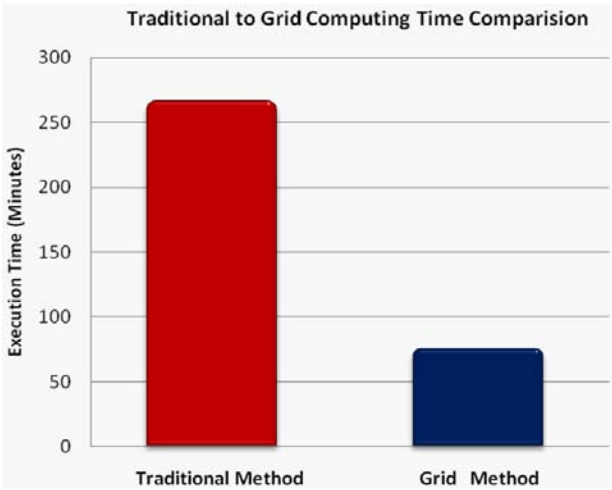

Figure 6: Normal and grid computing methods

For the real-time load balancing operations, It has been successfully by using SGE grid computing system and power world simulator.

Also, utilizing all the available GC resources was successfully done, in order to perform load forecasting operations. The forecast values were then returned to each relevant power systems where, if these values exceed a specific limit, decentralized load balancing operations were then executed. The load forecasting performance on different number of resources calculations are analyzed and the results are as illustrated in Figure 6.

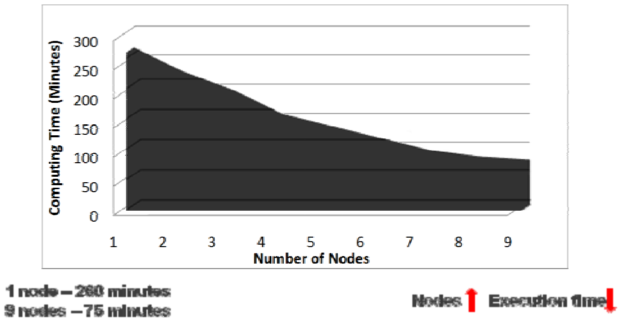

Figure 7: GC power load forecasting operation performance

Figure 6 illustrates that the time taken load forecasting reduces quite significantly when more GC resources were selected. Thus, by having the required resources, hourly load forecasting can be calculated where the forecast value shall be return to each power system for decentralized load balancing operations.

14 GC Priority and Advantages in Electrical Energy Engineering

In order to find the level of priority of GC technology to the power utilities companies, institutions and academies, first it should be identified what will be the benefits of this technology to them. These benefits are as follows:

a) Real-time data transmission among all power plants which dissolving the function of a centralized control centre.
b) Real-time load balancing process among all power plants to ensure that the power load are evenly distributed. In crucial situations such as power outages at one of the power plants, real-time load balancing could be perform to minimize the damage caused by the power outage.
c) Shorter time required for load forecast calculation which allows the power plant to react faster for the near future changes in power load demands, especially with increment of power demands due to weather changing and global warming phenomena.
d) GC increase PS reliability, increase transmission efficiency, and reduce storage and distribution outages
e) Enhance energy security
f) Reduce single point of fail by establishing the Integrated distributed generation
g) Offer clean energy and ensure more environmental benefits.

15 Power Application Backup System

Reliable power system is the major aim behind any scientific and industrial research trying to modify and develop power applications. Modern power systems as explained above are handling huge information which make reliability to risk ratio in a critical level.

In this paper new power system backup methodology is to be approved.

Current power system are working with traditional controlling - monitoring backup systems, which depends on (2xN) methodology. To assure most reliable and secured power systems, usually doubled backup system machines are installed to compensate any failing. In other words, as example within (N) operational power system machines usually additional (N) machines are sitting on behind waiting to replace any missed operation, see in figure 8.

In backup systems many parameters have to be considered and evaluated; like system place size, cost and conditions, energy consumed by the whole system, machines cost, repairing cost, environmental issues …etc.

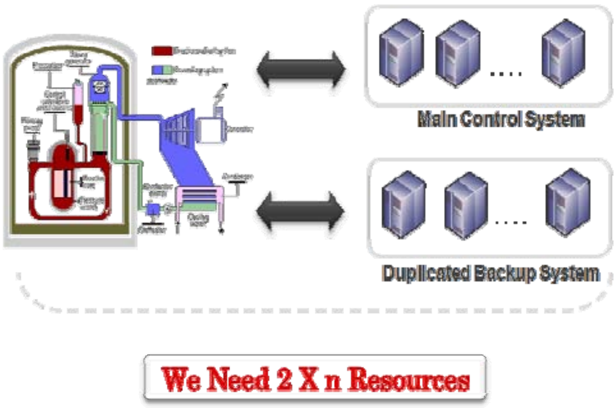

Figure 8: Conventional controlling/monitoring power system with backup system model

15 SWUGPS

In the South Westphalia University of Applied Sciences grid power system (SWUGPS) is set by integrating two major systems, Power plant module and SGE grid computing system. The power plant module is a small scaled module of nuclear power plant 'Mülheim Kärlich', which is a PWR (Pressured Water Reactor). The power system data is transferred to the grid computing resources via I/O device then to the server and database which are connected to the power system, see figure 9.

In SWUGPS both the power system server and database systems are located in the same host to avoid any communication problem.

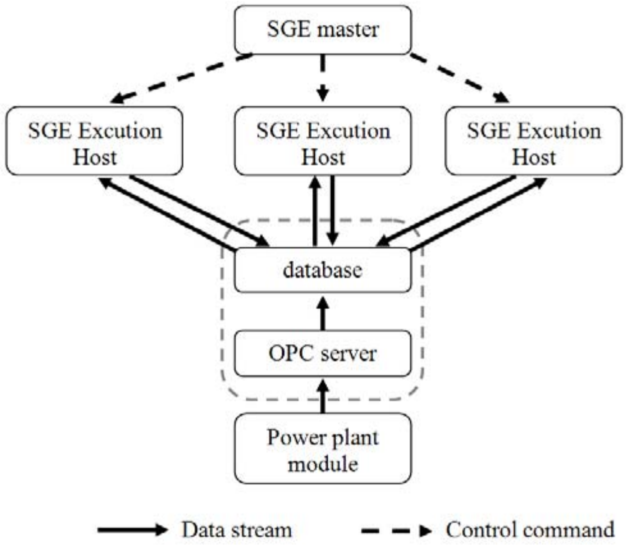

Figure 9: SWU grid power system Architecture

Figure 10 shows that SGE grid computing system is installed as computational part for the power plant applications, which is consists of SGE master (SGE Administrator and job manager), SGE shadow master (SGE master backup PC) and other execution hosts located in different geographical locations to process the computational jobs.

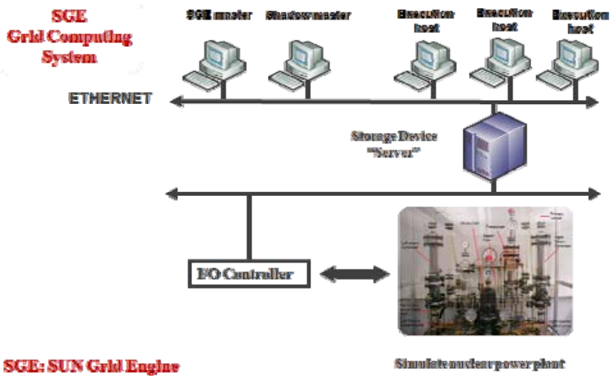

Figure 10: SGE system integration into power system

16 Developed reliable Backup System Methodology

As discussed above, the majority of conventional controlling/monitoring systems and methodologies (as shown in figure 8) have many limitations and difficulties. In this part grid computing technology by SGE middleware is proposed as a new tool to develop traditional power pack up system with more reliable, cheap and efficient one. The developed methodology is based on replacing the (2xN) backup system scenario (duplicated backup system) by (N+R) scenario. The main goal behind the new method is to reduce the backup system size, cost, limitations, host capacity, …etc.

By integrating grid computing technology, SGE master is responsible on detecting, controlling, and monitoring available resources and running jobs to maintain and assure system continuity and stability. Figure 11 illustrates grid computing (SGE) mechanism and structure. SGE master is sending job commands to the available grid computing resources and then to track these jobs and their results which are to be sent to the desired output point to react to these results.

Within the normal process SGE is behaving almost like the traditional system neither that utilized resources may not be owned by job owner (cheaper solution).

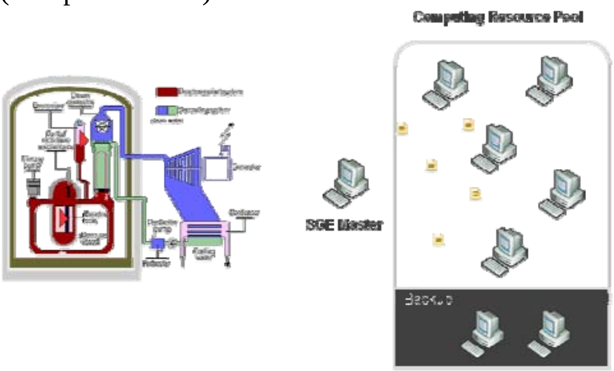

Figure 11: GC based controlling power system

When any problem is happening in the power system computational side (the abnormal case) which is the most important and critical situation for all power systems implementations, grid computing system has to react for that fault and compensate it within efficient and powerful way.

Form the definition of grid computing, all grid resources are playing dynamic roles inside the grid environment. During the operation period grid computing master is keeping controlling grid computing resources (busy or idle ones) that gives an advantage of advance knowledge of most compatible available machine.

Hence, whenever any problem may occurr in any computational grid resource, grid computing master is responding by resending missed job(s) or task(s) to the most applicable/compatible resource.

From figure 12, once any computing pool resources (white area) is broken SGE master is resending the pending job (waiting to be re-sent) to one of the available backup system machines (dark area) to compensate that failure, then to be considered as normal operational resource.

Following this new methodology may make power controlling and monitoring system working under dynamic, secured and reliable system within less backup system structure and cost.

Figure 12: GC based backup system

As mentioned above SGE middleware is a grid computing platform which, facilitates grid system monitoring and controlling via its easy and powerful graphical user interface (GUI).

Figure 13 illustrates SGE GUI which, shows three different status. In the top one, two power applications are sent (with "Jobid" 834 and 835). Both are working on clients exe5 and exe7. In the second screen (in the middle) shot job 835 is missed due to any reason (like network communication problem or HW or SW problem), job is sent to the pending status waiting for the next available resource to handle broken job. In the bottom screen, job 835 has been re-sent to exe3 (as available backup machine) to compensate exe7 breaking.

In this case only some machines are reserved for backup purpose and there is no need for duplicating the system.

Figure 13: SGE GUI shows GC reactive performance

4 Conclusion

Grid Computing as a new distributing computing technology gets benefit of all idle computers by contributing them into Computational Grid to process such problem needs many computational resources and goals to implement huge and difficult problems which need these resources without owning them, and to speed up computational process. Grid Computing is represented as the best Power future tool that new IT solutions are required for supporting trading activities, simulating power marketing decision, power controlling and predictions and major complex power engineering.
Grid Computing hold a lot of promise for the future power systems.

Grid computing facilitates the integration of old and new technologies in order to build redundant, stable electrical grids that can scale to large capacity. Integration of modern power systems with the grid computing will be necessary to enable monitoring and control of millions of small generators that will be embedded at distribution level. Research has indicated that SGE middleware has a very good online performance.

Future power grids will require efficient storage, transmission, distribution systems and intelligent control to enable the grids to deal with massive future energy demands and reliability that will be required. The modern power systems will comprise of millions of generation and storage points at local and remote locations. Many advanced new electrical technologies and information communications infrastructure.

Grid computing is an innovative tool to achieve the developed reliable and cheap backup system.

References:

[1] R. Al-Khannak, B. Bitzer. "Load Balancing for Distributed and Integrated Power Systems using Grid Computing". ICCEP07, Capri, Italy May 2007. IEEE http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?arnumber=4272368

[2] Taylor, G.A., Hobson, P.R., Huang, C., Kyberd, P. and Taylor, R.J. "Distributed monitoring & ontrol of future power systems via Grid computing." Retrieved August 20, 2006, from http://people.brunel.ac.uk/~eesrgat/research/pdf_pubs/IEEEPES2006.pdf

[3] Deak.O. (2005). "GRID SERVICE EXECUTION FOR JOPERA." Retrieved October 05, 2006, from http://www.iks.ethz.ch/publications/files/Oliver_Deak_MT.pdf

[4] Cascio, J. (2005). "Smart Grids, Grid Computing, and the New World of Energy." Retrieved October 4, 2006, from http://www.worldchanging.com/archives/002152.html

[5] Rajkumar Buyya and Srikumar Venugopal, CSIC communications, computer society of India' July 2005

[6] Foster, Ian and Carl Kesselman ed.: The Grid:Blueprint for a New Computing Infrastructure; Morgan Kaufmann; San Francisco; 1999.

[7] Grid Computing Info Centre (GRID Infoware), http://www.gridcomputing.com

[8] Joshy Joseph, Craig Fellenstein. Grid Computing, 2004.

[9] Qi Huang, Kaiyu Qin and Wenyong Wang, Development of a Grid Computing platform for electric power system applications. Power Engineering Society General Meeting, 2006. IEEE

[10] "Smart Electric Grid of the Future: A National "Distributed Store-Gen." Test Bed." Retrieved October 04, 2006, from http://www.ldeo.columbia.edu/4d4/testbeds/Smart-Grid-White-Paper.pdf

[11] "Grid Computing." Retrieved September 05, 2006, from http://en.wikipedia.org/wiki/Grid_computing

[12] Global Environment Fund. (2005). "The Emerging Smart Grid." Retrieved August 29, 2006, from http://www.globalenvironmentfund.com/GEF whitepaper_ElectricPowerGrid.pdf

[13] Yini Chen, Chen Shen, Wei Zhang and Yonghua Song. Grid computing infrastructure for power systems.

[14] Malcolm Irving and Gareth Taylor' Prospects for Grid-Computing in Future Power Networks, September 2003.

[15] Features of the Java Commodity Grid Kit. Available from: http://aspen.ucs.indiana.edu/gce/C536javacog/c536featuresOfCoG.pdf

[16] Parvin Asadzadeh, Rajkumar Buyya, Chun Ling Kei, Deepa Nayar and Srikumar Venugopal, Global Grids and Software Toolkits: A Study of Four Grid Middleware Technologies. Available from: http://www.gridbus.org/papers/gmchapter.pdf

[17] Gannon, D., Ananthakrishnan, R., Krishnan, S., Govindaraju, M., Ramakrishnan, L. and Slominski, A. "Grid Web Services and Application Factories." Retrieved October 03, 2006, from http://www.extreme.indiana.edu/xcat/publications/AppFactory.pdf

[18] D.Bevc, S.Zarantoneolla, N.Kaushik, I.Musat, "Grid Computing for Energy Exploration," Minisymposium on Grid Computing for Oil and Gas Industry, SIAM Conference on Parallel Processing for Scientific Computing, San Francisco, February 2004.

[19] S. Sheng, K.K. Li, Z. Xiangjun, "Grid Computing for Load Modeling," IEEE International Conference on Electric Utility Deregulation, Restructuring, and Power Technologies, April 2004. http://ieeexplore.ieee.org/Xplore/login.jsp?url=/iel5/9285/29506/01338053.pdf?tp=&isnumber=&arnumber=1338053