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A Grid Computing Based Power System Monitoring Tool Using Gridgain

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Abstract— With the advancement of civilization, Power Sector is undergoing drastic upheavals. With the ever increasing demand and dependence on electric power, protection of power system against failures remains a major challenge, particularly against cascading failures that lead to blackouts. There is a great demand for power systems protection that is scattered all around the globe. Effective monitoring of the power system parameters is a prerequisite in providing effective control and protection schemas. This paper advocates the use of grid computing in power system monitoring which discusses the suitability of grid computing to address the requirements of distinguished power system protection. Albeit, the Supervisory Control And Data Acquisition (SCADA) system is presently implied for monitoring power systems; yet it has its limitations. This paper proposes to use Grid Computing as an aid to the existing SCADA based power system monitoring & control framework and demonstrates is applicability by means of a grid based real-time power system monitoring system. The afore mentioned system has been deployed in desktop computers with GridGain 2.0 as middleware has been employed to set up the grid environment, all relevant details of the design framework has been shown.

Keywords- Grid Computing, Power System Monitoring, Gridgain 2.0.0, Jboss 4.2.3

I. INTRODUCTION

Due to the emerging technology, the computational resource playing a major role in different field, but how to get this high computation environment is still a topic of discussions. “Grid computing” , in general, is a special type of parallel computing that relies on complete computers with onboard CPUs, storage, power supplies, network interfaces etc. connected to a network (private, public or the Internet) by a conventional network interface, such as Ethernet. Grid computing is aggregation of large-scale cluster computing-based systems. Grid can be thought as a distributed system with non-interactive overload that involve a large no of files. The primary advantage of distributed computing is that each node can be used as service hardware, which, when combined, can produce a similar computing resource as multiprocessor supercomputer, but at a lower cost. One feature of distributed grids is that they can be formed from computing resources belonging to multiple individuals or organizations.

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. [1]

It is now widely accepted within the electrical power supply industry that future power systems will operate with significantly larger numbers of small-scale highly dispersed generation units that use renewable energy sources and also reduce carbon dioxide emissions. In order to operate such future power systems securely and efficiently it will be necessary to monitor and control the output levels and scheduling when comprising of such generation to a power system especially when it is typically embedded at the distribution level. Traditional monitoring and control technology that is currently employed at the transmission level is highly centralized and not scalable to include such significant increases in distributed and embedded generation. [2]

In this paper, a framework for monitoring of electric power systems has been presented that employs a grid computing as the backbone of ICT infrastructure . A Java based middleware namely GridGain has been employed in this paper. The remainder of this paper is organized as follows:

Section II gives a brief overview of grid computing of power monitoring. The grid computing paradigm and its suitability to monitoring of distributed future power systems has been discussed. Section III reflects the loop holes of the current monitoring system with SCADA. Section IV introduces the proposed monitoring solution implementing the native middleware GridGain 2.0.0 with the help of a JBOSS application server. Section V concludes the paper.

II. GRID COMPUTING: A BRIEF OVERVIEW

Modern power systems and electrical energy applications are demanding more and more computational power, which cannot be achieved by the existing computing technology installed in powers system 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 [5] 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 [6]. 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 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 [7].
Information and communication technologies (ICTs) have benefited the power systems in reliable and efficient operation and control for many years. Over the years, however, ICTs have progressed in leaps and bounds, while power system control centres, with their non-standard legacy devices and systems that could not take full advantage of the new technologies, have remained far behind. The ICT world has moved towards distributed intelligent system with Grid service [8]. It enables developing a distributed platform with robustness and flexibility, and helps managing the uncertainties and facilitating the transition processes.

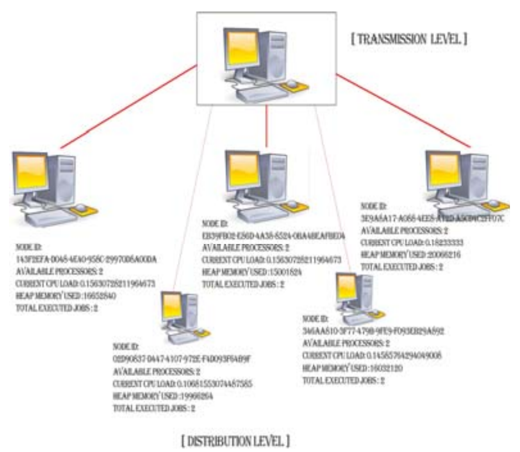

Fig 1. Monitoring at different levels of a power grid

A conceptual model of Grid service-based future power monitoring system is presented in figure 1. In the model, everything is a service. The services may have different granularity and may rely on other services to accomplish its job. The resources in the Grids are provided and managed by the standard resource services that deliver distributed computing and communication needs of the data and application services. The authorized users can easily access the required services through a powerful and user-friendly Grid portal.

In this paper, a number of PCs have been aggregated together to set up a grid environment that employs Grid gain 2.0.0 as middleware along with a application server Jboss 4.2.3. It is a collection of software components which provide many of the building blocks (services) necessary to create a Grid based application [9]. The most attractive feature of Grid gain was its java based nature. The hardware setup and associated details has been presented in Section IV.

III. ODISA POWER SYSTEM MONITORING SCHEME

In this paper we envision to implement a grid computing based framework that will work in tandem with the existing power system infrastructure to provide continuous monitoring facility. The existing SCADA infrastructure deployed are in Odisa only at the SLDC [12]. For future generation power systems, this promises to get more and more decentralized, effective monitoring need the help of advanced Information and Communication Technologies (ICT) infrastructure. Grid computing provides such infrastructure by means of making available easy resources and data sharing among constituent computers.

SLDC continually monitors integrated grid operations for quality, security and reliability of power supply in the state of Odisa in co-ordination with ERLDC in an easy way. It exercises supervision and control over the intra-state transmission system and it keeps account of the quantity of electricity transmitted through the state grid. It is responsible for carrying out real time operation of grid control and dispatch of electricity within the state of Odisa through secure and economic operation of the state grid in accordance with the grid standards and state grid code. It is responsible for optimum scheduling and dispatch of electricity within the state of Odisa in accordance with the contracts and entered into with the licenses or the generating companies operating in the state of Odisa.

Any power system infrastructure consists of generators, sub stations and distributed loads, which are interconnected to form the backbone of power grids. Please note the distinction of the terms power grid with grid computing at this juncture for any possible confusions in future. Herein we have implemented by means of grid computing, more specifically by means of a desktop grid computing, a distributed resource shared infrastructure where every grid substation has been embodied by a desktop computer. A test-bed comprising of desktop computers has been created by means of GridGain 2.0, a Java based middleware and associated software components. The Odisha power system has been taken as a case study. We are implementing grid computing in addition to existing SCADA system to facilitate and enhance the level of monitoring. We are trying to implement two new possibilities such as:

1. Predetermination of fault to alert the system.
2. Local monitoring of the grid substation

The existing monitoring scheme using SCADA is still has to be operated manually for control operation. Even the local power system monitoring data is transmitted over cable using which SLDC maintains state-wide power system information.

In SCADA implemented power system it is being used for monitoring and the decision is taken manually to control the operations. Using grid computing we can enhance the local monitoring and control of grid substation. As the entire grid will be connected to form a central grid monitoring is very important because to keep the system in stable condition we require:

- Synchronization monitoring of the generating unit
- Frequency monitoring at different levels
- Reactive power monitoring
- Quick response to the fault.

Since the monitoring at local level nearer to the fault location will help to achieve fast response and then facilitate removal of fault. Thus grid computing at this level will be quite useful, interfacing digital meters with the grid system and utilizing the various parameters to monitor. The proposal of implementing the grid computing at lower level prevents the system from islanding problem. This is because in the integrated system small faults integrate to form major fault leading to bigger fault in the system which can cause complete black out.

IV. Continuous Monitoring in a Grid Environment

The current power monitoring system provides a special functionality availed to the nodes which are potentially very high, and responsible to make the other small sub grid station to run but not for all. Using the following SLDC real-time monitoring concepts a grid based autonomous monitoring system has been designed.

- SLDC continually monitors the generating unit outputs against the dispatch instruction issued and bus voltages.
- SLDC continuously monitors actual MW drawl from central sector generators against the schedule by use of available SCADA equipment. SLDC also requests ERLDC and adjacent states as appropriate to provide any additional data required to enable this monitoring to be carried out.
- SLDC also monitors the actual MVAR drawl to assist in transmission system voltage management.

A. SET UP OF A LOCAL GRID

In a pool of system of specific number depending upon the performance, are connected to a LAN through a Switch/Hub with required configurations to run the setups required especially the gridgain 2.0.0.[10] Once the gridgain starts running in the network it senses automatically the other nodes where this service is running (fig-2). And based upon that at certain instant of time it creates localized cluster of nodes where the communication between the nodes is the speciality itself, where every node keeps track of every other node with all the required information.

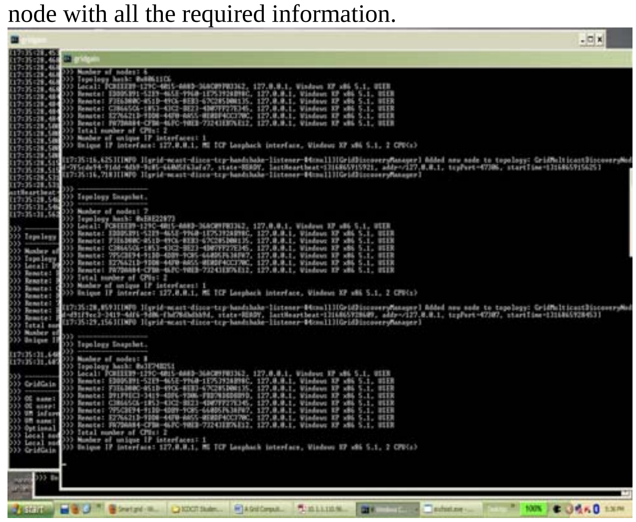

Fig 2. Formation of local grid according to current active nodes

B. MONITORING SYSTEM FUNCTIONALITIES

A server system needs to be launched to invoke a serializable service which will run in every client node, and will collect the remote node information as designed by the organizing service.
The service will automatically store the local node information in the local database of each node in a local database [10] with a fixed interval of time. In the server node the collected information of each nodes are displayed using a grid based web service with application server JBOSS 4.2.3a (fig-3).

In the grid environment this service is referred as a task to each node, hence each task need to be mapped to a specific node with the help of the unique Node id. Then after mapping of the jobs it's also need to be reduced i.e. to collect the results of the task. Here all the necessary information of all the nodes are gathered into the form of data, as a final result of reduce operation (fig-5).

The functionality of the service running at the node level depends a specific pseudo code.

Step1:Sense the network for availability of remote nodes

Step 2:GridTaskAdapter(map , reduce)

Step 3: remote _node=getAvailableRemoteNode();

Step4:arrayList = getAllNodes();

Step5:while(int var < arrayList.size())

Step 6:map (arrayList(i),new job())

Step 7:reduce(String result)

Step 8:Display the information using the application server JBOSS in the form of a webpage.

The task/Job for each node can be described as the pseudo code below.

Step 1:GridFactory.start();

Step 2:loc_grid=getLocalNode();

Step 3:I= loc_grid.getLineCurrent ();

Step 4:V=loc_grid. lineVoltage ();

Step 5:Oheat=loc_grid.OilTemperature ();

Step 6:Wheat=loc_grid.Winding temperature();

Step 7: tpos= loc_grid.TapPosition)_;

Step 7:conn=createLocalDatabaseConnection();

Step 8:conn.insert(proc,load,heap,jobs,conn);

a) *Step 9: return(I +V+Oheat+Wheat +tpos)*

These codes work at the back end, but don't have a good representative perspective. That's why we are relying on a application server Jboss 4.2.3, using its web-service the monitored information are displayed as web-pages.

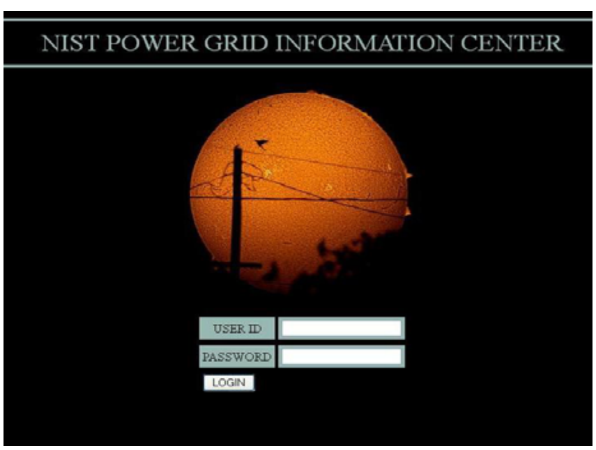

Fig 3. Authentication to enter the grid monitoring environement

This is the view of central login system. This enables authorized login. After login into the network the first page contains information about the online value of distribution company power, total power in the central grid, with drawl from the outside network as written central sector Generation and the total area frequency.

The various link provided in the left hand side will navigate to the detail information about the distribution company, total power and captive sector generation, monitoring bus bar voltages of substation and substation information

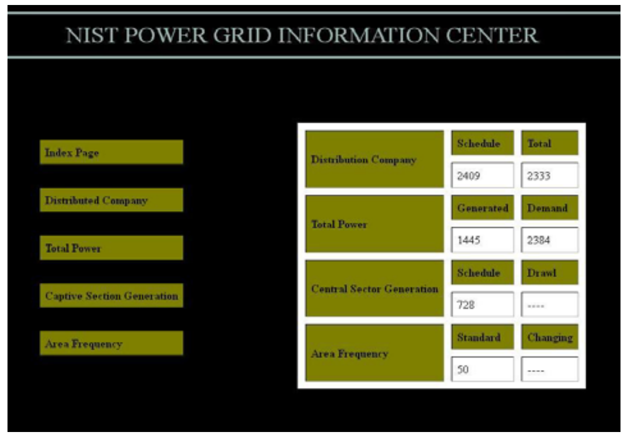

Fig 4.Shows different available functionality in a power grid monitoring environment.

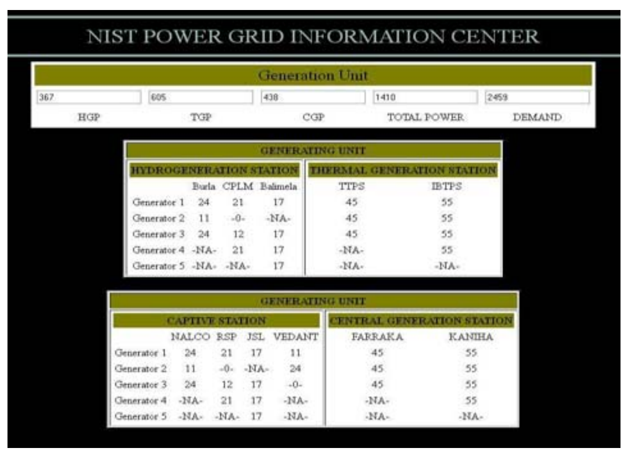

Fig 5. shows the various power scenario of generation unit at present.

The above table shows the power from various units such as hydro generation plant, thermal generation plant captive generation plant) the total power produced in the grid and present demand of the grid system.

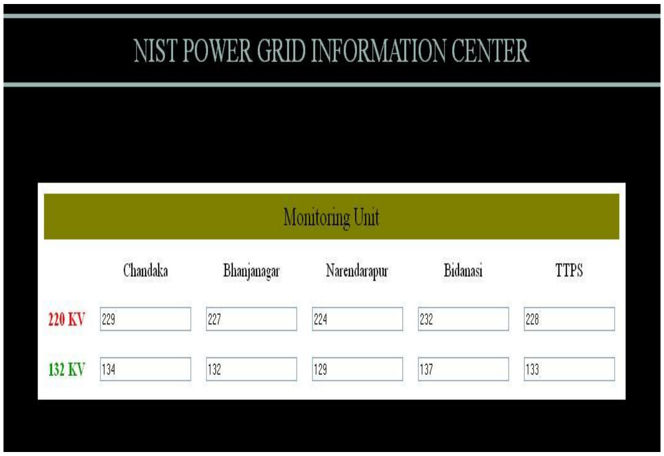

Fig 6. Shows the current monitored value of bus bar voltage at different substation level.

V. CONCLUSION

With the ultimate significance of the electric power industry, its effective protection is an area of utmost importance. Efficient monitoring and control of such power system is of prime importance. SCADA system deployed currently at limited to real life power system monitoring scenarios. This paper presents the use of grid computing for effective monitoring and control of power system. A sample implementation prototype using gridgain2.0 and JBoss 4.2.3 application server has been detailed. And thus a solution is ready to be deployed in a the real life scenarios with cost effectiveness and greater efficiency.
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