A Grid Computing Service for Power System Monitoring

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ABSTRACT

Extensively interconnected power grid has been a long cherished dream of the power system engineers. Recently, the incredible publicity of smart grid has brought about a revolution in the way the power system's operation and control functions are planned. However, attempts to interconnect power system grids have consistently resulted in failures, like cascaded failures, often leading to black-outs. Taking into account the real-time requirements to deal with power system diagnostic procedures, it is absolutely essential to have an effective and reliable monitoring of the entire system. In this paper, we have implemented the monitoring of Odisha power grid to fulfill the requirement of distinguished power system protection. This paper advocates the use of grid computing in power system monitoring. Even though, the Supervisory Control and Data Acquisition/Energy Management System (SCADA/EMS) system is presently being used for monitoring power systems; yet it has its boundaries. This paper proposes to use Grid Computing as a support to the existing SCADA/EMS based power system monitoring and control and demonstrates its applicability by means of a grid based synchronized power system monitoring system. Therefore mentioned system has been deployed in desktop computers with GridGain 2.0 as middleware.

Keywords

Grid Computing, Power System Monitoring, Grid gain 2.0.0, Jboss 4.2.3.

1. INTRODUCTION

Human beings continuously keep developing new methodologies to solve complex problems. Some of the fascinating techniques of modern world require enormous amounts of computation and data. The analysis of this huge data often via simulations can be facilitated by computing technologies like high performance computing, distributed and parallel computations which entail accessibility to huge computing power. Grid computing is gaining popularity as an efficient and cost-effective alternative to complex scientific problems. With global computing grids being setup all over the world, there is a need for the monitoring of this distributed computing power.

Electricity is the most adaptable form of energy used all over the world. The requirement for electricity is growing more rapidly than any other type of energy throughout the world. A fully functional power system grid is necessary to provide service that is reliable, cost-effective, safe, efficient, and environmentally responsible. Grid computing can be employed for monitoring the power system grid, which are distributed over geographical locations.

Increasing electrical energy requirement, energy usage patterns and modern lifestyles and have made the world fully dependant on power system. This instigated compulsory necessities for the operators to maintain high stability and reliability of the power grid. On the other hand, the power system is a highly nonlinear system, which changes its operations constantly. Consequently, it is very tricky and too costly to make the system be stable for all conflict. The system is generally designed to grip a single outage at a time. But, throughout the preceding decade several major blackouts were reported and all of them started with single outages.

Each major blackout was mandatorily and transparently reported to the community. The suitably written blackout reports help to reduce the operational risk, by intensification the system and its operations based on selected high risk contingencies.

In recent years, though the nature of power systems has seen major changes shifting towards more geographically scattered generations with lower capacities. Moreover, applications of deregulation and restructuring have posed serious challenges to existing power systems. Thus, it is obvious that there needs to be technology changes in order to monitor and control future generation electric power systems that include wind energy, solar energy, and hydro energy sources apart from existing generations [11].A power system might be unstable if there is any insufficiency in its protection and monitoring. So effective monitoring assumes utmost importance of power system.

In recent years, the nature of power systems has been changing towards a more distributed infrastructure. In India instead of small number of high capacity generating stations, large numbers of low power generating stations are being deployed [3]. So, its monitoring also needs to be distributed in nature. Grid computing, a computing paradigm getting wide popularity in recent times, has been employed to offer a solution to monitor the power system.

In this paper, a framework for monitoring of electric power grid has been presented which employs a grid computing as the backbone of ICT infrastructure [6]. A Java based middleware namely GridGain [2] has been employed in this paper. The rest of this paper is organized as follows: Section II gives a brief overview of grid computing. The grid computing model and its appropriateness to monitor the distributed future power grids has been discussed. Section III provides the key features of the current monitoring system.

2. GRID COMPUTING: A BRIEF REVIEW

Grid computing is normally regarded as a computing strategy to entirely use the spare computing resources. However, the viewpoint of grid computing can be used in engineering case to play an significant role in power system dispersed monitoring, control and distributed parallel computing[2]. It provides a software layer that depends on grid computing for hardware hold up, to seamlessly put together the distributed computing resources and put into practice high-performance operations and computing in electric power system.

Information and Communication Technologies (ICTs) have benefited the power systems in reliable and well-organized operation and control for numerous years. In past few years, the ICTs infrastructure has improved in leaps and boundaries. But power grid control centres, with their irregular inheritance devices and systems that could not take full benefit of the new technologies. Thus they have remained far behind. The ICT world has inspired towards distributed intelligence system with Grid service [6]. It enables developing a distributed platform with heftiness and flexibility, and helps managing the doubts and facilitating the evolution processes.

An abstract model of Grid service-based future power systems is shown in figure 1. In the model, the whole paradigm is a service. The services may have diverse granularity and may rely on other services to achieve its job. The resources in the Grids are provided and managed by the standard supply services that convey distributed computing and communication needs of the data and request services. The authorized users can easily access the required services through an easy-to-use grid portal. In this paper, a number of PCs have been aggregated jointly to set up a grid environment that employs Grid Gain 2.0 as middleware. It is a collection of software mechanism which provides many of the building blocks (services) essential to create a grid based application [4]. The most remarkable feature of Grid Gain is its Java based nature. Power generating stations continuously generate the power which is read by digital meter and store in database. Monitoring system reads the data from the database at particular time interval and distributed the load to the end user depending upon the requirement of power.

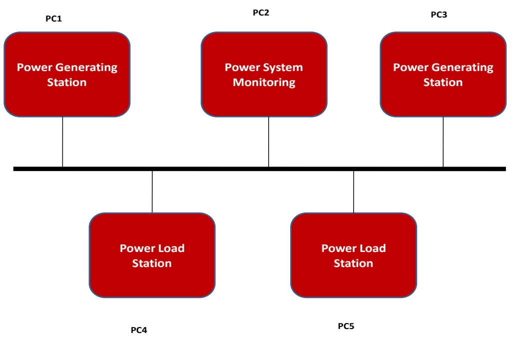

Figure 1: Diagram demonstration of Hardware configuration and Services allocation in the grid computing based power system

3. POWER SYSTEM MONITORING AS A GRID SERVICE

Monitoring can provide information about power flow and demands, as well as the quality of power. Monitoring can be a very important analytical model, identifying problem situation on a power grid before they can cause conflict or interruptions. Monitoring can provide information about power flow and demand and assist to recognize the cause of power system disturbances [3]. It can also possible to identify the problem situation on a power grid before they cause disturbances or interruptions in the power grid. This monitoring program needs flexibility, powerful data processing, comprehensible reports, and easy access to information. Power monitoring programs are structured using a set of basic machinery like power quality and/or energy demand monitors, data storage, download information.

A grid environment involves major sharing of resources within various virtual organizations. There arises a need for mechanisms that enable continuous detection and monitoring of grid-entities like resources, services and activity. This can be quite challenge to the self-motivated and geographically-distributed nature of these entities. The main function of monitoring is regulated employment of grid resources. Any grid infrastructure should therefore have a monitoring system devoted to this task, which should provide a minimum – dynamic resource discovery, information about the grid activity, information about resources, and performance diagnostics.

The current monitoring system of power grid provides a particular functionality availed to the nodes which are potentially very high and responsible to build the other small sub grid station to run but not for all. With the following state load dispatch center (SLDC) [13] real-time monitoring concepts a grid based self-governing monitoring system [16] has been designed.

- SLDC regularly monitors the generating unit outputs against the transmit instruction issued and bus voltages.
- SLDC endlessly monitors actual MW draw from central sector generators against the agenda by use of available SCADA equipment. SLDC also requests ERLDC and neighboring states as appropriate to provide any extra data required to enable this monitoring to be carried out.
- SLDC also monitors the real MVAR drawl to assist in transmission system voltage supervision.

3.1 Monitoring of Odisha Power Grid

In this paper we envisage to implement a grid computing based framework that will work in conjunction with the existing power system infrastructure to provide continuous monitoring facility. In Odisha, the obtainable SCADA/EMS infrastructures are deployed only at the SLDC [13]. For future generation power systems, this promises to get more and more decentralized, useful monitoring need the help of sophisticated Information and Communication Technologies (ICT) communications. Grid computing gives such infrastructure by means of making accessible easy resources and data sharing among component computers.

SLDC frequently monitors integrated grid operations for quality, security and reliability of power supply in the state of Odisha in co-ordination with eastern region load dispatch center (ERLDC) [13] in a simple way. It exercises direction and control over the intra-state transmission system and it keeps account of the amount of electricity transmitted through the state grid. It is accountable for carrying out real-time operation of grid control and dispatch of electricity within the state of Odisha through secure and economic operation of the state grid in agreement with the grid standards and state grid code. It is answerable for optimum scheduling and dispatch of electricity within the state of Odisha in accordance with the contracts and entered into with the licenses or the generating companies working in the state of Odisha.

Any power system set up consists of generators, distributed loads and sub stations are interconnected to outline the backbone of power grids. Please note the dissimilarity conditions of the power system with grid computing at this juncture for any possible confusion in future power system. In this we have implemented by means of grid computing, more particularly by means of a desktop grid computing, a distributed resource shared infrastructure where every grid substation has been personified by a desktop computer. A test bed comprising of desktop computers has been formed by means of Grid Gain 2.0[2], a Java based middleware and linked software components. The Odisha power system has been used as a case study. The implementation of grid computing in addition to existing SCADA/EMS system is to make easy and improve the level of monitoring of the power grid. We are trying to implement the new possibilities such as: local monitoring of the grid substation.

The existing monitoring scheme of power system using SCADA/EMS is still has to be manipulated by hand for the control operation of the power grid. Yet the local power system monitoring data is transmitted through cable using which SLDC implements state wide power system information.

In SCADA/EMS implemented power system it is being use for monitoring and the decision is taken by hand to control the operations. Using grid computing we can improve the local monitoring and control of grid substation. As the entire grid will be associated to form a central grid monitoring is very significant because to keep the system in stable condition we require synchronization of monitoring the generating components, monitoring of frequency at diverse levels, reactive power monitoring system, and quick response to the liability.

Since the monitoring of power system at local level nearer to the fault location to identify the fault which will help to attain fast response and then make easy elimination of fault. Therefore grid computing at this level will be quite supportive, implementing digital meters with the grid system and employing the various parameters to monitor. The suggestion of implementing the grid computing at root level prevents the power system from islanding crisis. This is because in the integrated system minute faults put together to form major fault leading to superior fault in the system which can cause complete black out in the power system.

3.2 Designing the Power Grid Monitoring Service

A server system needs to be launched to invoke a continuous service which will run in each client node, and will gather the remote node information as planned by the organizing service [2].

IBM db2 database is installed in all local desktop grids as well as in server machine to carry out data intensive application. In the server node the composed information of each nodes are displayed using a grid based web service with application server JBOSS 4.2.3a. In the grid environment this service is referred as a task to each node, hence each task needs 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 is gathered into the shape of data, as a final result of reduce operation (figure-2).

The service will automatically store the local node information in the local database of each node in a local database [2] with a predetermined interval of time. In the server node the composed information of each nodes are displayed using a grid based web service with relevance server JBOSS 4.2.3a (figure-9).

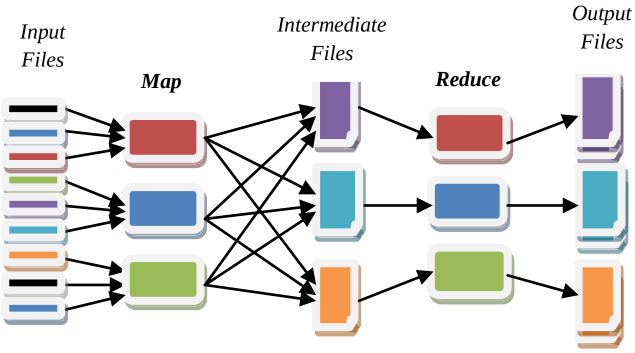

Figure 2: Map and reduce of job among current active nodes

The functionality of the service [16] running at the monitor level based on a specific pseudo code as shown in fig-3.

```
Step 1:  Sense the network for availability of remote nodes
Step 2:  GridFactory.start();
Step 3:  GridTaskAdapter(map , reduce);
Step4:  remote _node=getAvailableRemoteNode();
Step 5:  arrayList = getAllNodes();
Step 6:  while(int var < arrayList.size());
Step 7:  map (arrayList(i),new job());
Step 8:  reduce(String result);
Step 9:  individualResult[ ]=result.split("#");
Step 10: while(int var < individualResult.size);
Step 11: storeDb(individualResult[var]);
```

Figure 3: Service running at the monitor level

The task/Job for Distribution unit can be described as the pseudo code is shown in fig-4.

```
Step 1: date=new Date();
Step 2: loc_grid=getLocalNode();
Step 3: timeSlot=(date.getHour()*60+date.getMinute())/15;
Step 4: schedulePower= loc_grid.getPower ();
Step 5: name=loc_grid.getName();
Step 6: conn=createLocalDatabaseConnection();
Step 7: conn.insert(name,schedulePower,timeSlot,date);
Step 8: return(name+schedulePower+timeSlot+date);
```

Figure 4: The task/Job for Distribution unit

The task/Job for Hydro generation Unit can be described as the pseudo code is shown in fig-5.

```
Step 1: date=new Date();
Step 2: loc_grid=getLocalNode();
Step 3: while(int var < arrayList.size());
Step 4:      power[var] = loc_grid.getPower(var);
Step 5:      sign[var] =loc_grid.grtPowerSign(var);
Step 6:      totalPower +=power[var];
Step 7: name=loc_grid.getName();
Step 8: conn=createLocalDatabaseConnection();
Step 9 : conn.insert(name, power.length(), power, sign,
totalPower, date);
Step 10: return(name + power.length() + power + sign +
totalPower + date);
```

Figure 5: The task/Job for Hydro generation unit

The task/Job for Thermal generation Unit can be described as the pseudo code is shown in fig-6.

```
Step 1: date=new Date();
Step 2: loc_grid=getLocalNode();
Step 3: while(int var < arrayList.size());
Step 4:      power[var]=loc_grid.getPower(var);
Step 5:      totalPower +=power[var];
Step 6: name=loc_grid.getName();
Step 7: conn=createLocalDatabaseConnection();
Step8: conn.insert(name,power.length(),power,totalPower,
date);
Step9:   return(name+power.length()+power+totalPower+
date);
```

Figure 6: The task/Job for Thermal generation unit

The task/Job for Captive generation Unit can be described as the pseudo code is shown in fig-7.

```
Step 1: date=new Date();
Step 2: loc_grid=getLocalNode();
Step 3: while(int var < arrayList.size());
Step 4:      power[var]=loc_grid.getPower(var);
Step 5:      totalPower +=power[var];
Step 6: name=loc_grid.getName();
Step 7: conn=createLocalDatabaseConnection();
Step8:   conn.insert(name,   power.length()   ,power,
totalPower, date);
Step9:   return(name+power.length()+power+totalPower+
date);
```

Figure 7: The task/Job for Captive generation unit

The task/Job for Captive substations Unit can be described as the pseudo code is shown in fig-8.

```
Step 1: date=new Date();
Step 2: loc_grid=getLocalNode();
Step 3: while(int var < arrayList.size());
Step 4:      power[var] = loc_grid.getPower(var);
Step 5:      sign[var] =loc_grid.getPowerSign(var);
Step 6:      destPlace[var]=loc_grid.getPlace(var);
Step 7:      totalPower +=power[var];
Step 8: name=loc_grid.getName();
Step 9: conn=createLocalDatabaseConnection();
Step 10 : conn.insert(name, power.length(), power, sign,
place, totalPower, date);
Step 11: return(name+power.length()+power+sign+place+
totalPower+date);
```

Figure 8: The task/Job for Captive substations unit

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.

In figure-9 various links are provided in the left hand side, which will navigate to the detail information about the distribution company power, total power in central grid and captive sector generation, with draw from the outside network as written central sector Generation and the total area frequency, monitoring bus bar voltages of substation and substation information.

The figure-10 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.

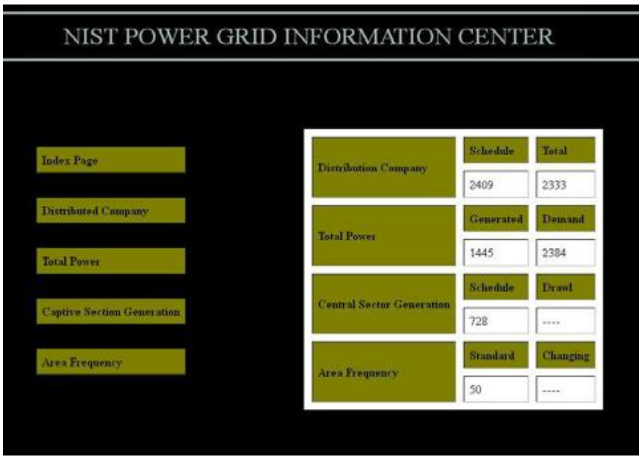

Figure 9: Different available functionality in a power grid at Monitoring environment.

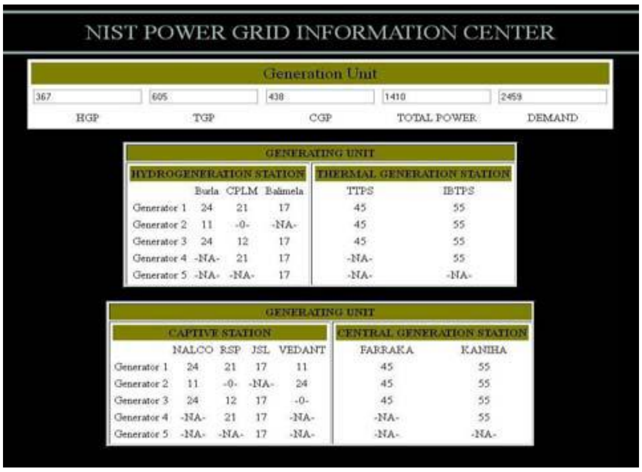

Figure 10: The various power scenario of generation unit of Odisha power grid.

Figure 11. The monitored value of current bus bar voltage at different substation level.

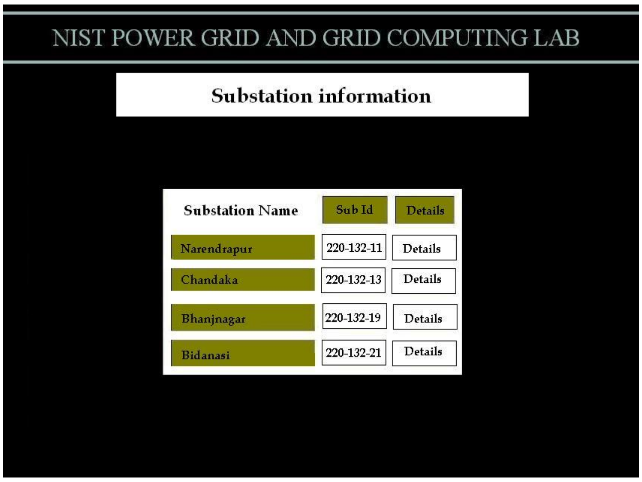

Figure 12: The monitored value of different substation of Odisha power grid.

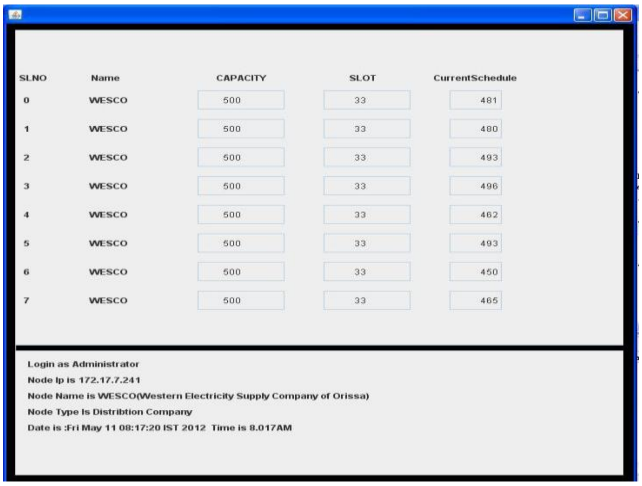

Figure 13: The local monitoring of Distribution unit of WESCO.

In figure-14 shows the local monitoring of hydro generating stations of Balimela unit of Odisha power grid. It has eight generating stations out of which only three are currently working. Capacity column specifies the total capacity of power that can produce but the currentvalue column specifies the currently produced power. In figure-15 shows the local monitoring of thermal generating stations of TTPS unit of Odisha power grid. It has seven generating stations out of which only five are currently working. Capacity column specifies the total capacity of power that can produce but the current generated column specifies the currently produced power.

The figure-11 shows the power monitoring at different substation of Odisha power grid. It will represent the current voltage of the bus at the different substation units. But in figure-12 gives the detailed information about the different substations. In figure-13 represents the local monitoring at distribution level. Name column indicates the distribution company name, capacity column specifies the maximum power that can distributed, slot column specifies the timing slot, currentschedule column specifies the current power distributed amount to the end users.

In figure-16 shows the local monitoring of captive generating stations of RSP unit of Odisha power grid. It has eight generating stations. Capacity column specifies the maximum capacity of power that can produce but the power column specifies the currently produced power. In figure-17 shows the local monitoring of substation units of Odisha power grid. It indicates how much power is transmitted from RSP to different destination locations. Capacity indicates maximum power transmitted from source to destination and power column specifies currently how much power is transmitted.

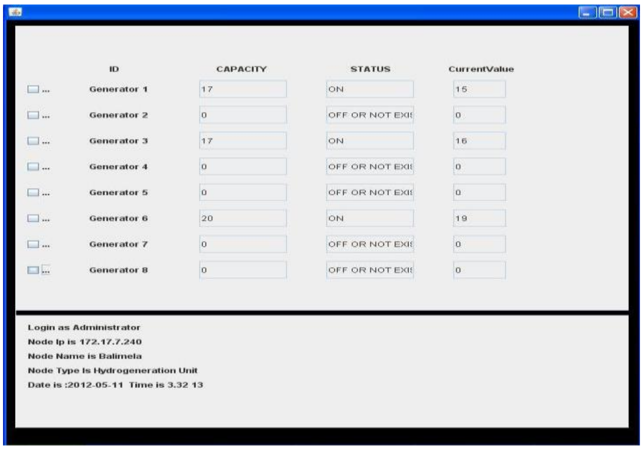

Figure 14: Shows the local monitoring of Hydro generation unit.

Figure 15: Shows the local monitoring of Thermal generation unit.

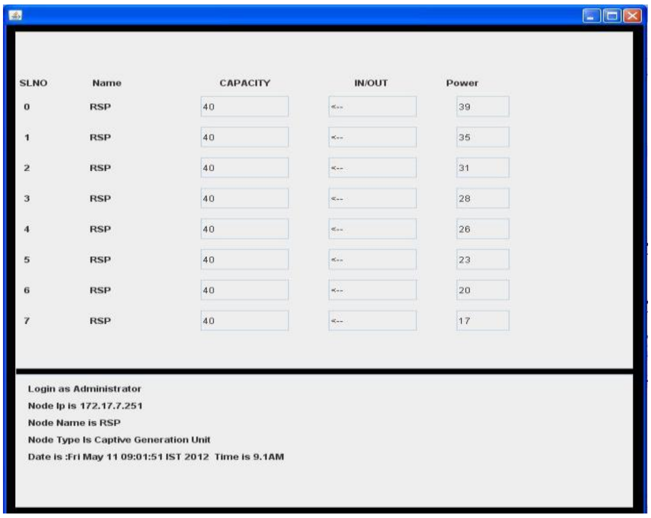

Figure 16: Shows the local monitoring of Captive generation unit.

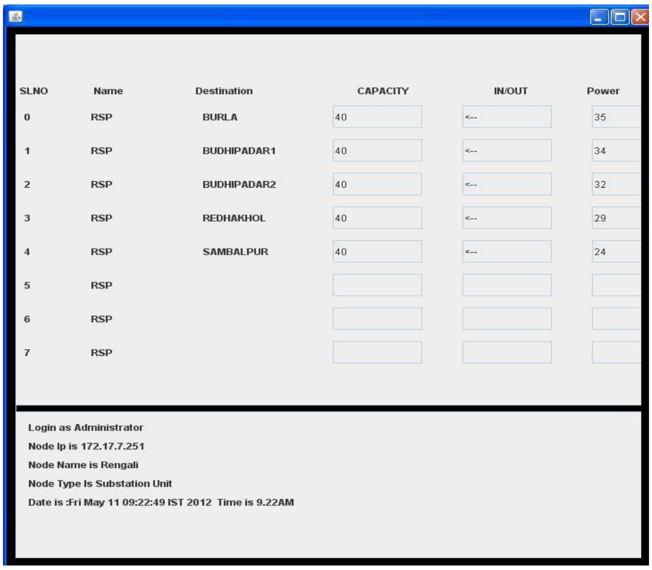

Figure 17: Shows the local monitoring of Substation unit.

4. CONCLUSION

The current scenario of this paper reflects the monitoring part of various desktop grid nodes which provides the detail explanation of all the nodes connected along with different parameter. But SCADA/EMS in Odisha is only deployed currently at restricted places to real life power system monitoring scenarios. This paper presents the use of grid computing for efficient monitoring and control of power system. A sample implementation prototype using gridgain2.0 and JBoss 4.2.3 application server has been exhaustively depicted. Future scope of this work can be implementing various existing schemes of power system control mechanism in our grid system.

5. REFERENCES

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