GRID COMPUTING BASED MODEL FOR REMOTE MONITORING OF ENERGY FLOW AND PREDICTION OF HT LINE LOSS IN POWER DISTRIBUTION SYSTEM

[1]C.Senthamarai, [2]A.Krishnan

[1]Assistant Professor., Department of MCA, K.S.Rangasamy College of Technology, Tiruchengode,

TamilNadu-637215,India.

[2]Dean, K.S.R. College of Engineering, Tiruchengode,TanilNadu-637215, India.

E-mail: senthukumaran20023@yahoo.com, : a_krishnan26@hotmail.com

ABSTRACT

Grid Computing has been identified as an important new technology in scientific and engineering fields as well as many commercial and industrial enterprises. Grid Computing is a form of distributed computing that involves coordination and sharing of computing application, data storage or network resources across dynamic and geographically dispersed organizations. In short, it involves virtualizing computing resources. Grids provide an infrastructure that allows for flexible, secure, coordinated resource sharing among dynamic collections of individuals, resources, and organizations. In this paper we develop an application framework for remote data monitoring in Power Distribution System by using Grid Computing. Using this framework it is easy to monitor and control the parameters such as voltage, load, frequency and power factor in electrical power distribution system. By monitoring all these parameters the line loss can be predicted and can be reduced so that the revenue will automatically be increased in the Power Distribution system by using this Application framework.

Keywords: Grid Computing, Distribution system, Electrical Network, Monitoring and control, Line loss

INTRODUCTION

The term `Grid Computing' is relatively new and means a lot of different things to a lot of different people. It has been used as a buzzword for any new technology to do with computing, especially computer networking, Grid Computing, or Network Computing, is intended to provide computational power that is accessible in the same way that electricity is available from the electricity grid - you simply plug into it and do not need to worry about where the power is coming from or how it got there. Thus the Grid is defined as

1. The flexible, secure, coordinated resource sharing among dynamic collections of individuals, institutions and resources [4,5,6]
2. A type of Parallel and distributed system that enables the sharing, selection and aggregation of geographically distributed autonomous resources dynamically at runtime depending on their availability, capability, performance, cost and users quality of service requirements [1]

The objective of this paper is to propose and develop a model of computing grid for Remote Monitoring data and to predict the line loss in the power distribution system

While transmitting and distributing power to meet the consumers demand, Power losses occur in the EHV, HV and LV lines and also in the transformers. This technical loss in the power system is an inherent characteristic and it cannot be totally eliminated but can be reduced to an optimum level which will increase the revenue when monitoring and controlling of lines are done as and then by using the emerging technology Grid Computing.

MOTIVATION

Computing, data, and collaboration Grids [4] [5] are an approach for building dynamically constructed collaborative problem solving environments using geographically and organizationally dispersed high performance computing and data handling resources. The overall motivation for current large-scale, multi-institutional Grid projects is to enable the resource and human interactions that facilitate large-scale science and engineering such as aerospace systems design [10], high energy physics data analysis [11], large-scale remote instrument operation [12], collaborative astrophysics based on virtual observatories etc. In this context, the goal of Grids is to provide significant new capabilities to scientists and engineers by facilitating routine construction of information and collaboration based problem solving environments that are built on-demand from large pools of resources. Functionally, Grids will provide tools, middleware, and services for:

- Building the application frameworks that allow discipline scientists to express and manage the simulation, analysis, and data management aspects of overall problem solving.
- Providing a uniform look and feel to a wide variety of distributed computing and data resources.
- Supporting construction, management, and use of widely distributed application systems.
- Facilitating human collaboration through common security services, and resource and data sharing.
- Providing remote access to, and operation of, scientific and engineering instrumentation systems.
- Managing and securing this computing and data infrastructure as a persistent service.

This is accomplished through two aspects:

- o A set of uniform software services that manage and provide access to heterogeneous, distributed resources.
- o A widely deployed infrastructure.

LAYERED GRID ARCHITECTURE

The components that are necessary to form a Grid are shown in Figure 5. The layered Grid architecture organizes various grid capabilities and components such that high-level services are built using lower-level services. Grid economy [13] is essential for achieving adaptive management and utility-based resource allocation and thus influences various layers of the architecture:

_ *Grid fabric software layer*: Provides resource management and execution environment at local Grid resources. These local Grid resources can be computers (e.g. desktops, servers, or clusters) running a variety of operating systems (e.g. UNIX or Windows), storage devices, and special devices such as a radio telescope or heat sensor. As these resources are administered by different local resource managers and monitoring mechanisms, there needs to be Grid middleware that can interact with them.

_ *Core Grid middleware layer*: Provides Grid infrastructure and essential services, which consists of information services, storage access, trading, accounting, payment, and security. As a Grid environment is highly dynamic where the location and availability of services are information about Grid resources, constantly changing, an information service provide the means for registering and obtaining providers and users to be part of the Grid community, and allows

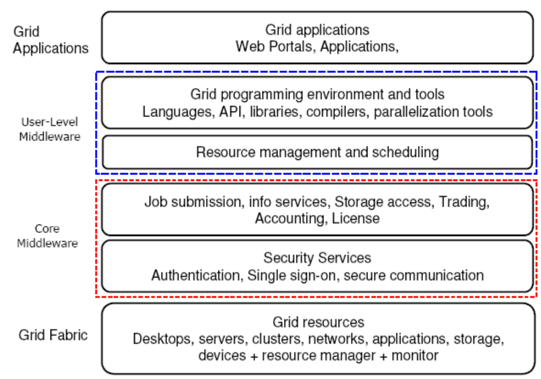

Figure 1. Layered Grid architecture

them to develop strategies to maximize their objectives. Security services are also critical to address the confidentiality, integrity, authentication, and accountability issues for accessing resources across diverse systems that are autonomously administered.

_ *User-level middleware layer*: Provides programming frameworks and policies for various types of applications, and resource brokers to select appropriate and specific resources for different applications. The Grid programming environment and tools should support common programming languages (e.g. C, C++, Fortran, and Java), a variety of programming paradigms (e.g. message passing [14] and Distributed Shared Memory (DSM) [15]), and a suite of numerical and commonly used libraries. Resource management and scheduling should be transparent to the users such that processor time, memory, network, storage, and other resources in Grids can be utilized and managed effectively and efficiently using middleware such as resource brokers.

_ *Grid applications Layer*: Enables end-users to utilize Grid services. Grid applications thus need to focus on usability issues so that end-users can find them intuitive and easy to use. They should also be able to function on a variety of platforms and operating systems so that users can easily access them. Therefore, an increasingly number of web portals are being built since they allow users to ubiquitously access any resource from anywhere over any platform at any time.

TYPICAL ELECTRIC POWER SUPPLY SYSTEM

Electric power is normally generated at 11-25KV in a power station [7]. To transmit over long distances, it is then stepped-up to 400KV, 220KV as necessary. Power is carried through a transmission network of high voltage lines. Usually, these lines run into hundreds of kilometers and deliver the power into a common power pool called the power grid. The power grid is connected to load centers (cities) through a sub-transmission network of normally 33KV (or sometimes 66KV) lines. These lines terminate into a 33KV (or 66KV) substation, where the voltage is stepped-down to 11KV for power distribution to load points through a distribution network of lines at 11KV and lower. The power network, which generally concerns the common man, is the distribution network of 11KV lines or feeders downstream of the 33KV substation. Each 11KV feeder, which emanates from the 33KV, branches further into several subsidiary11KV feeders to carry power close to the load points (localities, industrial areas, villages, etc.,).

At these load points, a transformer further reduces the voltage from 11KV to 415V to provide the last-mile connection through 415V feeders (also called as Low Tension (LT) feeders) to individual customers, either at 240V (as single-phase supply) or at 415V (as three-phase supply).

Lack of information at the base station (33KV sub-station) on the loading and health status of the 11KV/415V transformer and associated feeders is one primary cause of inefficient power distribution. Due to absence of monitoring, overloading occurs, which results in low voltage at the customer end and increases the risk of frequent breakdowns of transformers and feeders.

PROPOSED MODEL

Our work mainly aims at building a prototype for monitoring the data residing at different substations[16]. By installing our grid application framework on the substations as in Figure 2.

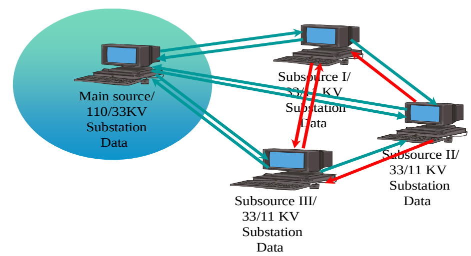

Figure 2. Proposed Model

The data present in any substation can be monitored at any moment using our grid application framework, which will give the following benefits [8,9]

- Real Time monitoring and control of substations
- Improved power quality
- Load forecasting
- Load survey data and Network Analysis of HT systems
- Reduction in line loss
- Revenue improvement

The following method is implemented in our grid application framework using Globus toolkit for calculating the % of HT Line Loss.

<u>Line Loss calculation</u>

- **Connected Load in KVA = CL**
- **Maximum Load in the feeder in Amps = P**
- **Energy sent out in the feeder in units = E**
- **Feeder Voltage in Kilovolts = V**
- **Power Factor = PF**
- **Study Period in Hours = H**
- **Diversity Factor = DF**
- **DF = CL/1.732 * V * P**
- **Load Factor = LF**
  LF = E/1.732 * V * P * PF *H
- **Load Loss factor LLF = 0.8 * LF ^{2} + 0.2 LF**
- **Name of the Feeder = x**

- **Cumulative capacity = KVA**
- **Distance in KM = L**
- **Resistance of conductor per Km = R**
- **Feeder Voltage in KV = V**
- **A = $(KVA/ V * DF)^2 * L * R/ 1000$**
- **Energy loss in a feeder during the study period Hrs L1 = A * LLF * HRS**
- **Energy Loss in DTS during the study period Hrs = L2**
- **Total Energy loss in Kilowatt Hrs**
  B = L1 + L2
- **Input to the Feeder in KW**
  C = (1.732 * V * P * PF) + A
- **Energy sent out**
  D = C * LF * H
- **Percentage of HT Line Loss (L)**
  L = B * 100 / D

EXPERIMENTAL RESULTS AND ANALYSIS

Four Pentium IV machines were used for our work. Globus toolkit has been installed in all 4 machines to set up the grid environment. The data were collected from the feeder X. The Sample Data and results are given for the proposed model.

Without using Grid Computing Model (GC) the Load is monitored for the range from 1Amps to 300 Amps and keeping the voltage 9.9 KV and Power Factor =0.85 as constant the % of HT Line loss is calculated. Then by using Grid Computing Model (GC) for the same load range and improving the voltage by 11.3 KV and improving Power factor by 0.92 again the % of HT Line loss is calculated and the both results were given in the Table 1.

Table 1: Load Vs. HT Line Loss

Load (in Amps)	HT Line Loss in % (Without GC)	HT Line Loss Reduction (With GC)
1	3.344	3.295
50	17.321	15.333
100	22.558	18.947
150	22.341	19.150
200	22.158	19.208
300	21.867	19.300

The Figure 3 shows the % of HT Line Loss for the Table 1. It can be understood that when the Load is increased the Line Loss is gets increased.

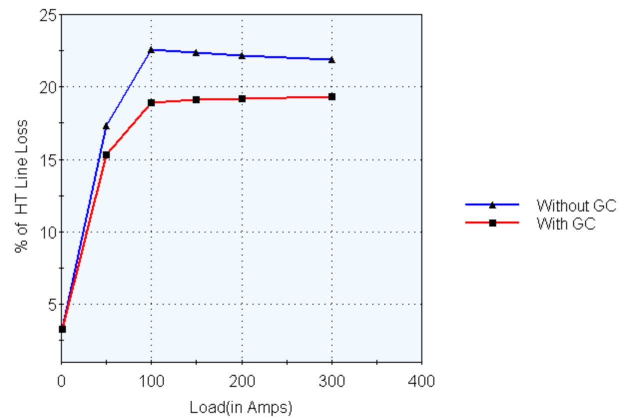

Figure 3. Load Vs. HT Line Loss

By varying the Voltage and keeping PF=0.92 and Load=220Amps the % of HT Line loss is calculated before and after Grid computing (GC) and the results are given in the Table 2.

Table 2.Voltage Vs. HT Line Loss

Voltage in KV (Before GC)	HT Line Loss in %	Voltage raise in KV(after GC)	% of HT Line Loss Reduction
9.0	20.737	10.93	20.638
9.5	20.513	11.2	20.436
9.8	20.392	11.16	20.335
9.9	20.353	11.26	20.298

The Figure 4 shows the voltage vs. % of HT Line Loss for the Table 2. Thus by using Grid computing model the % of HT Line loss is reduced by raising the voltage .

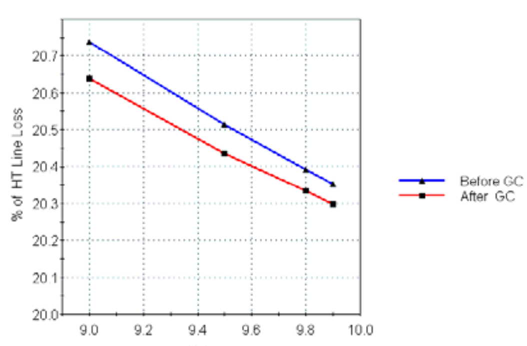

Figure 4. Voltage Vs. HT Line Loss

By varying the Power Factor and keeping the voltage=11.1 KV and Load = 215Amps the % of HT Line loss is calculated before and after Grid computing (GC) and the results are given in the Table 3.

Table 3: Power Factor Vs. HT Line Loss

Power Factor	**HT Line Loss in % (Before GC)**	**HT Line Loss Reduction (After GC)**
0.70	22.516	12.32
0.75	22.186	13.82
0.78	22.013	14.83
0.79	21.959	15.37

The Figure 5 shows the % of HT Line Loss for the Table 3. It can be understood that when the Power Factor is increased the Line Loss is decreased.

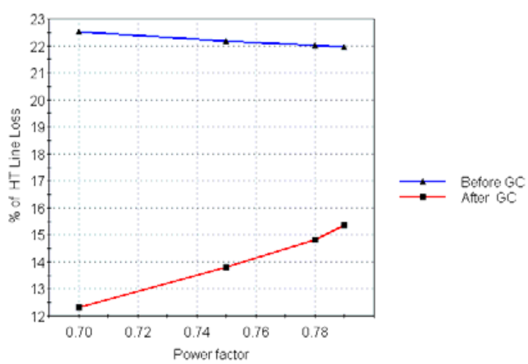

Figure 5.Power factor Vs. HT line loss

By monitoring the parameters for example voltage and power factor using this model, and if the power factor value lies below 0.70 the instruction is given to raise the power factor to 0.95 by the addition of capacitor banks. By increasing the power factor the line loss gets decreased to 1% approximately by using the above model.

REVENUE ANALYSIS

Total Number of Units consumed Per Day = 170 Million Units (Approx)
Total Line Loss in TNEB = 18%
Cost Per Unit = Rs. 3.00
Total Revenue Loss Per day
= 170 X 1000000 X 18/100 X 3
= Rs. 918,00,000

Suppose if the line loss is reduced to 1% from 18 % using Grid computing model the revenue will be increased to an appreciable level.

By Using Grid Environment = 1% (approx)
= 91800000 X 1/100
= Rs.9, 18,000 /Per day

CONCLUSION

Monitoring and controlling the parameters such as voltage, load, power factor, KVA, KW, KWH, can reduce KVAR in electrical power distribution systems using our grid computing application framework and the line loss can be reduced. Existing HT Line loss in TNEB is 18 %. By using our Grid Computing Model framework it is easy to monitor and control the Energy Flow and HT line loss in the Electrical Power grid dynamically. Also decisions can be made faster than the existing method. This will improve the Electrical System stability, reliability, availability and Maintainability. Our experimental results prove that when the Load increases Line Loss also increases and when power factor and voltage are increased the Line loss can be reduced. Thus by using this model the line loss can be minimized and hence the performance of the system gets improved and the revenue will also automatically gets increased.

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