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Power Consumption Analysis

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Abstract- **Even though India being the world's third largest electricity producer and consumer after the United States and China, the nation still suffers from frequent power outages that last as long as 10 hours. Further, about 25% of the population, about 300 million people, have no electricity at all. Efforts are underway to reduce transmission and distribution losses and increase production further. The term blackout is used to describe a widespread cutoff or loss of supply of electrical power, especially as a result of a shortage, a mechanical failure, or overuse by consumers. It is well known that blackouts happen only rarely and they are usually caused by a sequence of low probability outages.**

Keywords: **Blackout, outages, cascading failures, intentional and unintentional removal.**

I. Introduction

Modern electric power systems have three separate components- Generation, Transmission and Distribution.

A. Generation

Electric power is generated at the power generating stations by synchronous alternators that are usually driven either by steam or hydro turbines. Most of the power generation takes place at generating stations that may contain more than one such alternator-turbine combination.

B. Transmission

Depending upon the type of fuel used, the generating stations are categorized as thermal, hydro, nuclear etc. Many of the generating stations are remotely located. Hence the electric power generated at any power station has to be transmitted over a long distance to load centers that are usually in cities or towns through transmission lines to the distributed end. Thus transmission sector for grid forms a crucial link between the generator and distributor of optimal power to the households.

C. Distribution

An electric power distribution system is the final stage in the delivery of electric power; it carries electricity from the transmission system to individual consumers.

Any disturbances in operating parameters of the grid can lead to fatal consequences or a blackout scenario or outage. Power outages are categorized into three different phenomena, relating to the duration and effect of the outage:

A transient fault is a momentary (a few seconds) loss of power typically caused by a temporary fault on power line. Power is automatically restored once the faults cleared.

A brownout fault is a drop in voltage in an electrical power supply. The term brownout comes from the dimming experienced by lighting when the voltage sags. Brownouts can cause poor performance of equipment or even incorrect operation.

A blackout refers to the total loss of power to an area and is the most severe form of power outage that can occur. Blackouts which result from or result in power stations tripping are particularly difficult to recover from quickly.

Outages may last from a few minutes to a few weeks depending on the nature of the blackout and the configuration of the electrical network[9]. While the majority of power failures from national grids last only a few hours, some blackouts can last days or even weeks, completely shutting down production at companies and critical infrastructures such as telecommunication networks, financial services, water supplies and hospitals[7].

Furthermore, it is likely that power blackouts will become more frequent, and the fact that energy from decentralized, “volatile “renewable sources is not well aligned to work on electricity grids that were designed 50 or 60 years ago. Also, as more and more grids are interconnected, a blackout in one region can trigger a domino effect that could result in supra-regional blackouts[7].

Although the detailed analysis of the chain of events after a particular blackout is useful in suggesting specific weaknesses that can be rectified, it gives little guidance on the overall problem of whether society is rationally balancing the blackout risks with the costs of investing in increased reliability. Quantifying the overall blackout risk would allow this balancing by putting an approximate value on reliability[9].

II. Proposed Architecture

Since cascading failures have adverse effects on human life, therefore it is important to have a reliable and efficient system that can minimize the effect of blackout.

Consider a network comprising of four nodes N_1, N_2, N_3 and N_4 each having its own topological structure, operating parameters and its operating limits as shown in the dependency graphs.

The following figure shows the architecture that we have created in order to reduce the frequency of blackout:

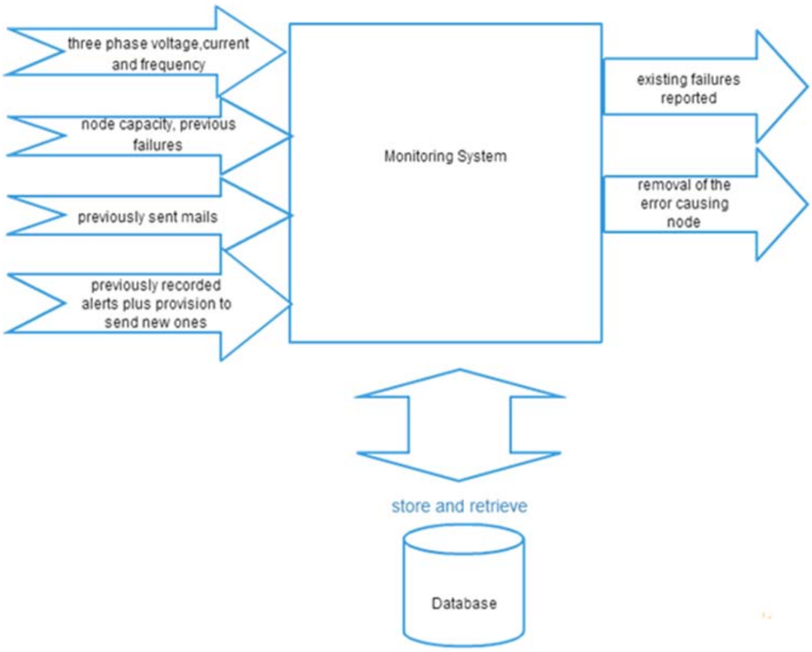

Fig. 1 Proposed Architecture

The inputs to our system will be the following:

- The database provides input as three phase voltage, three phase current and frequency.
- The information about every node like region, area, node_id, node name, node state.
- The real time information about the neighborhood of the areas affected by the blackout.
- The historic data showing all the sent emails regarding the failure or the alert reported at every situation.
- The database is connected directly to our system as shown in the figure.

Our aim is to create a system which analyzes the power that was given to the node takes governing actions on the entries and then go for the removal of the error causing entity or the node which after removal causes least damage to the system.

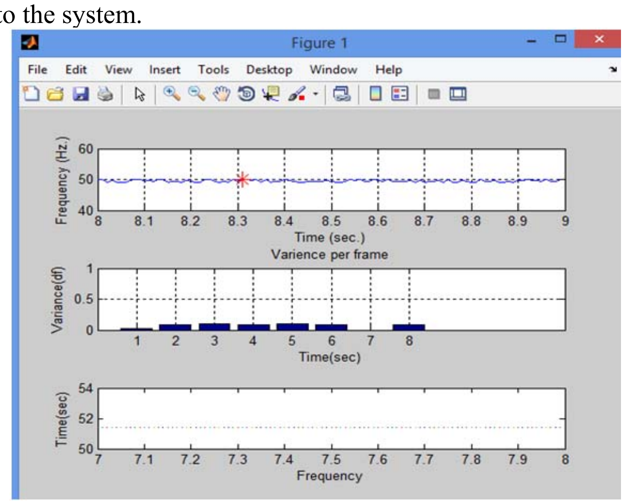

Fig. 2 Frequency vs Time for a node

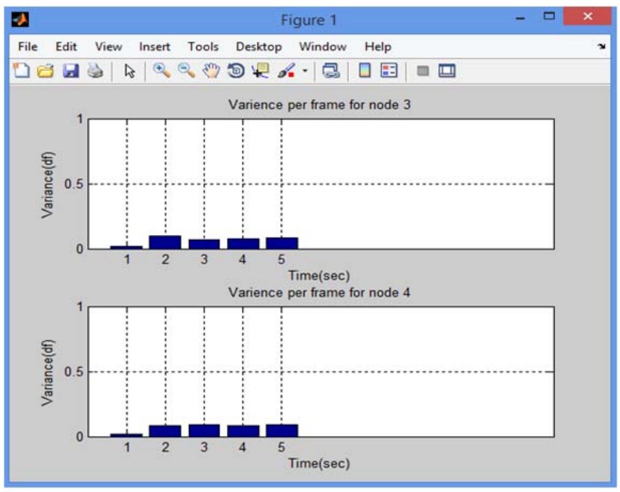

Fig. 3 Overall operation of the system

III. IMPLEMENTATION

As shown in fig.1, our network contains four nodes namely n1,n2, n3 and n4. Each of the node contains seven parameters Va, Vb, Vc, Ia, Ib, Ic and f where Va, Vb and Vc are the voltage parameters, Ia, Ib and Ic are the current parameters and f is the frequency of the respective node.

A. Data Set

The data set includes the real time values of the parameter with respect to date and time. This means that the values of the parameters are being updated after a specific interval of time which is in milliseconds.

B. Node Capacity and Line Capacity

A node operates in a free-flow region of $L_k \leq C_k$, otherwise the node is assumed to fail and removed from network.

Where L_k is the initial load and C_k is the capacity of the node.

$C_k=\lambda.L_k$

Where λ=tolerance parameter and $\lambda\geq1$.

Hence the capacity of node is directly proportional to the initial load[12].

The capacity of a line is defined as the maximum load that can be carried by the line.

Capacity of a line $C_i= (1+\alpha)L_i$.[12]

Where L_i is the initial load at node i.

C. Value Check

Value of the frequency parameter is checked after every 20ms. If the value is in the operating range of the frequency then the process is continued and the value of the frequency parameter is checked after the next 20ms. But if the value of the frequency parameter is in the alert range then the values of the frequency for the next 50ms is checked continuously. If 30 or more values among the 50 values lie in the alert range then an alert is sent to the admin for the further procedure through email. This alert can result to the removal of node.

D. Removal of Node

There can be two types of node removal:

1) Intentional Removal

Intentional Removal means removals performed after initial condition and before failure occurs.[12]. Our system checks the values of the parameters. If 30 out of 50 values are detected in the alert range then an email is sent including the information about the alert.

2) Unintentional Removal

Unintentional Removal means removals performed after the failure condition occurs[12].

When the failure occurs, our system checks the logs of the values of the parameters and then finds the node responsible for the failure and sends a mail which includes the information of the node. And then the node responsible for the failure is isolated[2,3].

But the removal of nodes can have a much more devastating consequence when the intrinsic dynamics of flows of physical quantities in the network is taken into account. In a power transmission network, for instance, each node deals with a load of power. The removal of nodes, either by random breakdown or intentional attacks, changes the balance of flows and leads to a global redistribution of loads over the network. This can trigger a cascade of overload failure[13,14].

Now, when a node is intentionally removed which is connected to nodes i and j, the load generated by node iis given by

$L_i^g = (D_i+1)(N-1)$,

where D_i is the average shortest path length from node i to all the other nodes.

Nodes whose load L_i is much larger than L_i^g contribute much more to handling than to generating load. These are the most important nodes for the network to operate. The removal of one such node may cause overloads on a number of other nodes. More precisely, if a node i is removed from the network, the total load on the remaining nodes increases by at least the amount L_i-$2L_i^g$.[15,16].

Now this alert is sent to the admin so that further process can be continued.

After removal of a node, the load that was given to the respective node must be divided into the remaining node or else the load can cause damage if given to a single node. [12].

IV. Related Work

Cascade-based attacks on complex networks by Adilson E. Motter, Department of Mathematics, CSSER, Arizona State University, Tempe, Arizona 85287 and Ying-Cheng Lai, Departments of Electrical Engineering and Physics, Arizona State University, Tempe, Arizona 85287.

V. Conclusion

We have introduced a method by which the frequency of the blackout scenarios can be reduced. The method is based on Intentional and Unintentional Removal of the nodes before the failure of the nodes by sending an email containing the alert information about the node which can cause the failure and affect the remaining nodes in the network leading to blackout scenario. Also by sending the information about the node which caused the blackout can reduce the time of black out by eliminating the responsible node from the network.

Acknowledgement

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