Intelligent Power Management System

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***Abstract*—The paper deals with an Intelligent Power Management System that can help modernize the existing Power Grids with newer technologies such as AI and ML. Incorporating AI can help to improve the power generation supply and overall management. The Power Management System can ensure reliable power supply.**

***Index Terms*—PMS(Power Management System), AI, ANN, ML, Rational**

I. Introduction

Power Management System or PMS is made to manage the Power Grids and ensure the maximum optimal performance of the power grids. This ensures that the power is produced and used in a rational way. The system is integrated with AI and ML to make it more advanced and easily implementable. Power is the fuel of the economy. All of the machines need energy this is supplied as power, and power used with respect to time gives energy. The demand for energy is increasing day by day and the existing power systems are not enough to supply the power according to the growing demands, Intelligent Power Management is designed to change according to real-time usage demands, automatically reducing downtime and improving the quality of power in power grids. The output is to ensure a quality supply of rational power across the grid.

II. Power Management System

The power management system (PMS) is the system that maps the power usage to the power generation. The system manages the power grid and manages the power supply in an area. The system is designed with separate modules for specific outputs. The modules include Power Generator Management, Power Usage Data Collection, Meta Data Formation, and Overall Management

The system works via a feedback mechanism that takes the Power Usage data from the end users and generates the metadata of the power usage data and uses this data to generate the commands that may include power generation management commands to even accident or error triggers that can be generalized to management commands.

The management can be simplified with the help of the ML modules which can accurately predict the power usage data and also anticipate the repairs this can alert the authorities about the needs that might occur in the near future. This make the PMS more efficient and thus can also ensure the quality of the power along with quantity. Most of the time the organizations depend on the quantity thus this reduces the quality of power and this is directly proportional to the longevity of the appliances. Reliable and quality power ensures that appliances don't frequently break down.

In most of the places there is frequent power outages and the repair is not anticipated and the downtime may be long enough from hours to even days. This is due to faulty Power Management System and this is the main base for Intelligent Power Management System. Availability of Quality Power should be the new standard so that the productivity improves thus developing the world.

The proposed system works by collecting the usage data from the end users by incorporating the I-o-T devices such as smart meters. The grid can also be enhanced by using the actuators which are also embedded systems that can manipulate the power grid components such as circuit breakers, transformers, etc... This can primarily be used as a feedback mechanism to regulate the power grid supply. The data available from the grid can further be processed to obtain the set of meta data that is useful for the Neural Networks inside the power management system to learn about the power grid and make accurate predictions and also the generator management commands. The generator management is crucial to maintain the supply to the power grid. Traditional systems doesn't have the capacity to manage all these data effectively and manipulate them to generate useful information.

III. Architecture

The architecture of the main block in the system consists of various subdivisions or sub-blocks which incorporate the features as proposed. The system is designed to have multiple feature and this is to be a single software, thus modular

approach is used to completely isolate the different blocks as it can work independently and effectively. This approach is made to reduce the load and dependency on hardware to complete the complex processes. The main architecture prescribes the basic information as well as power flow in the grid.
The main architecture includes the following blocks:

- Power Generation management
- Power Supply Management
- Usage Data Collection and Server Management
- Power Load Management and Forecasting
- Automated Error Triggering

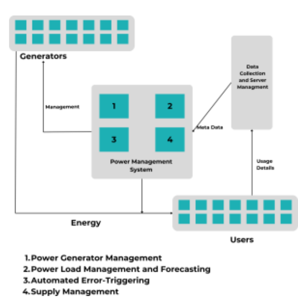

Fig. 1. Power Management System Architecture

A. Power Generation Management

In a Power Grid there will be multiple power sources and from these all sources Power can be generated but the characteristics differ like Fuel, Peak Capacity, Efficiency, all the data is available about these generators but only the peak generation capacity is utilized at real-time. The efficiency and Fuel Consumption matters as it may increase the carbon foot print of the energy. The global warming is causing serious threat to humanity and this is directly dependent on the carbon footprints. The aim of the global nations is to reduce the use of renewable energy sources in Power Generation. This is implemented but not optimized as there is multiple issues. The Power Usage data is primarily available but there is latency associated with the power grids, In real-time the Generated power is not used at the moment it needs to reach the end users and they needs to consume it and the usage data needs to travel back to the server. The to and fro transmission takes several seconds or minutes sometimes as there is computational latency associated with these widely scaled embedded systems . This latency prevents real-time error free data availability this is crucial for the Power Generator management. Thus this is a wide scale problem and with the solution to this problem we would find the effective way to manage generators.
The ANN is incorporated to learn the user data and train itself to be capable of predicting the real-time consumption load accurately. This prediction can be used to rationally manage the power generators efficiently . The Power Generators are

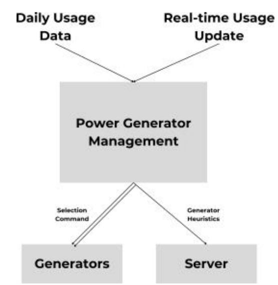

Fig. 2. Power Generation Management Sub-module

selected based on large amount of Considerable factors such as fuel availability, Carbon footprints, Power Generation peak capacity etc. These all can't be easily calculated in fraction of seconds by normal methods. AI Systems are incorporated to maximize the efficiency in generator management by automated selection of the generators to meet the real-time demand. The AI can easily rank the generators based on heuristics and select the most rational one and produce best output.The generation also depends on the climate as the consumption will be higher in the summer rather than in winter thus the linear dependency cant be easily studied, the AI can map the non-linear data and produce a favorable command based on the same
The AI incorporation can easily help in cases such as, In day-time most power grids have peak supply from Solar Power Plants and this is the most easiest available power source with less carbon footprints. If there is a power need in the night time the Solar power is not available simple programs can't deal with these kind of situations but AI can train itself with multi-dimensional data and select the optimized way of power generation. In traditional systems more power is generated and less amount of power is consumed and there is a slight buffer between them so as to maintain a sudden surge. The AI can easily reduce the buffer to nearly optimal values. The ideal value is zero for the buffer by maintaining the supply and demand at the same rate . This can ideally be possible by further training of the AI by providing large data of years to learn.
The generator is primarily selected on the basis of multiple factors and is focused on demand in the power grid. The dynamic generator ranking is provided by the ANN and based on the heuristics the best generator is selected. The power regulation is focused over this module and this specific module. This is the most crucial step in maintaining the equilibrium as well as reducing the carbon footprints of the power grid.

B. Power Supply Management

The Power Supply Management includes data collection and usage statistics across the power grid and using this data to ensure quality supply of power in desired quantity. This is important as reliable power supply should be available to all the people around the world so that development reaches every corner around the world. This data can be used to manipulate the generation as well as used to calculate the real-time prices so that people can get power at cheaper rates than usual this is beneficial for the people as well as the Power Grid owners to get more profit than usual.

The data is also beneficial to help in studies regarding premium power supply investments so that companies can plan for anticipated repairs and also charge the users additional fee for such causes. Usually these purchases are made in real-time and the payments are made by the users in the near-future and they did always have to pay additional as the interest for the money sped this is reduced by the help of the newer iteration of the System Incorporated with AI.

The Module collects data from the grid regarding the usage and accordingly manages the supply. The Power Generation module assists by providing the adequate power for the grid. The main focus here is on the uninterrupted supply of the power and also focuses on the quality of power as the supply of the power determines the quality of the power. The Quality power is the deficient power and is good fur the equipments. The quality power is reliable and the productivity of the society increases with this. This specific module can monitor the whole power grid map, collect and analyze the data to produce the accurate output. The output of the entire power grid system is depend on the supply of the power

When there is an error or overload the Power Supply Management module takes the charge of handling. Rather than cutting off the entire power in the grid unit. It can selectively trigger off the higher load modules and take actions to reduce the load. This is capability of the smart Io T devices and AI assistance.//

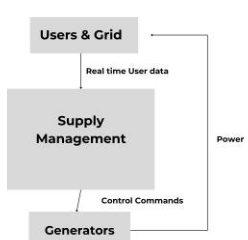

Fig. 3. Power Supply Management Sub-module

C. Usage Data Collection and Server Management

Usage data collection is done in the existing power grids but is not completely automated and not done in real-time but the data is relevant but the post time availability makes it irrelevant and of no other use than just billing. The newer system is planning to include the newer smart meters which can send the user data at real-time to the servers the available data can be used to ensure the quality of the power as well as be used to make sure that the grid is error free and working fine. The system needs embedded system for the same and a centralized data base that can hold the values of the large amount of users as well as the power appliances across the grid.

The meta data available from the server can be used for management the server is made as a separate module along with the AI module to withstand the load and handle the entire grid efficiently

The idea of maintaining separate database is to ensure the data integrity and to make sure that data abstraction works fine. Both the aspects are of importance that a data leak can cause several problems. The system is designed to maintain high level of data safety for the users.

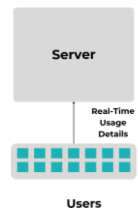

Fig. 4. Data to Server Uni-channel communication

The system will be having a server that is used to process the incoming usage data from the users. It is a uni-channel communication and the data is saved on to the database by the module. Separate module is responsible for communicating with the users so that the whole process is similar to transactions.

D. Power Load Management and Forecasting

Power Load Management is the essential task to maintain the equilibrium between user demand and supply the equilibrium needs to be maintained so as to make the grid effective. The main disadvantage in all the existing system is the latency associated with the power usage data collection, this affects the management is a negative way as sudden spikes in usage disturbs the equilibrium and often incur in losses or power outage. This has been one of the major concern from the I-o-T integration as it was costly yet still ineffective. The main idea is to incorporate an ML that can predict the accurate power usage that can calculate the spikes and manage the demand in a better possible way so that it can result in reliable power supply.

The database holds the value of the usage data when there is a spike (positive or negative), the load management system checks for the load and calculates the exact values passes it on to the server and modules so that they can access it and along with this it broadcasts the message across the power-grid so that the smart devices can take the appropriate actions. This is important as real-time mapping of input to output can be

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 12 | Dec - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

only done with the help of Load Management.The system is essential as it can also easily figure out overload, take the necessary actions and inform the authorities regarding. The action part is specified by the Supply Management module.

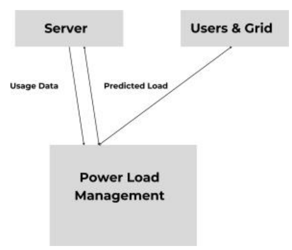

Fig. 5. Load Forecasting

E. Automated Error Triggering

The Errors are usual in the Power grid and this is not easily detectable at the management side, but since data collection is implemented the usual change is predictable, But when there is unusual changes the ML can recognize it this can be used to trigger automated error checking mechanism that can run itself to find the point of issue and inform the authorities to correct it. This process only takes few minutes and is accurate that it can also inform the end users about the same also it can anticipate the errors in case of Climate. The higher wind, thunders all of the natural things can be predcited these all affect the power consumption directly but the linear connection cant be mapped easily but ML can help with the same by mapping the data and producing the anticipates error triggers so that the users as well as the authorities stay alert so that errors can be tolerated easily and in an effective manner rather than going for outages

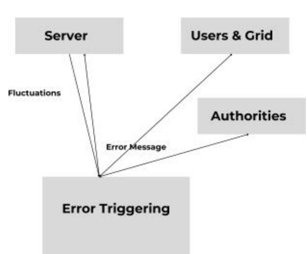

Fig. 6. Error-Triggering

IV. Comparison with Existing System

There are existing power grid management systems across the world but in most of the cases such as in rural areas the grid is mostly operated manually this is not efficient and causes accidents as well as power outages. This is the main area of scope where the system can be implemented. The older systems are manual time consuming as well ass inefficient. Most of the people are yet not familiar with electricity. In developing nations itself there are places where power is only available for just one day per week for which farmers have to wait to complete the process of agriculture. The better power grid may not show its effect directly in the light in a short period but it will reduce the cost of operation across multiple sectors providing better quality products at a lower rate and a better lifestyle to majority of the people. Consider the example of agriculture, if power is available continuously the crop will be better as there is proper irrigation, pest control etc.. The farmers wont have to wait for long hours the cost of production will also decrease as power will be rather available at a lower cost this will increase the profit at the root level.// The profit is available to all markets and this also helps people to rely more on grids and thus indirectly reduce the power usage from Non-renewable energy thus reducing the carbon emissions. In case of Industries when there is shortage of power they rely on fossil fuel powered generators thus operation can produce more pollutants, If there is reliable power from Renewable sources they can use it and run on a lower operation cost. // The system can be coupled and scaled across nation to develop a united power grid so that the intra territorial power excanhges can be easily monitored and the usage of Non-renewable energy can be reduced//

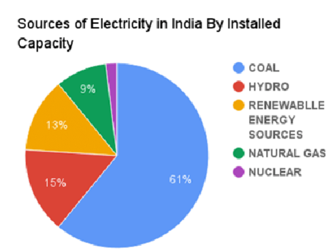

Fig. 7. Pie chart showing of distribution of power sources

The above figure shows that India is primarily dependent on the non-renewable sources the primary dependency can on non-renewable sources can be brought down to renewable sources reducing the carbon emissions. The dependency is due to wastage of renewable energy and the higher cost of implementation of the power plants based on renewable energy. The older system doesn't provide the scope for further improvements and with the newer system the investments can be planned accordingly and be made efficient

V. Comparison with SCADA

SCADA stands for Supervisory Control and Data Acquisition, and it's a software system that monitors and controls industrial processes in real time. SCADA systems are essential for managing and monitoring power plants, especially wind and solar power plants.
Although SCADA is useful in Power Generation Management we cannot couple it to a power grid to manage the supply. The problem is that the power supply management needs an individual high speed network to handle the large load that might occur in peak time. This might not be useful otherwise.

The Proposed model Helps to manage the grid by presumptions and assumptions rather than real time data dependency this is a better option as real-time data availability is a large issue along with latency. Latency issues need to be solved in the grid to ensure maximum efficiency this is crucial. The ML can accurately predict the power outcomes and provide management suggestions
Although the Idea might seem similar. Both the systems differ the Predicted system can work with less computational power than SCADA

CONCLUSION

In conclusion the Smart Power Grid management System equipped with multiple application specific AI and ML modules can revolutionize the existing power grid by providing a better management option and also proving most rational output and from the power grid. The idea of equipping ML and AI will help in better management of the power systems. The better management results in the reduced cost of operations as well as reliable power supply. The system can ensure error and hassle free operation and can also reduce pollution. The Power grids can also focus on the power quality along with the quantity of supply. This will result in long term outcomes such as better lifestyle,less pollution, reduced cost of power, reduced price of goods and services etc...// All these will be the long term results of the system and can produce quick and anticipated actions. The manual operation needs time to adapt to a change but the automation will help in the better adaptation with the situation.

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