SMART HOME ENERGY MANAGEMENT

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ABSTRACT

In this technical world there exists a crisis in energy supply and there should be a method to save the energy for the future purposes. Given the growing energy demand and declining fossil energy supply, the design of Smart Home Energy Management will help in monitoring energy usage in one's house and inform the user about his/her activity by analyzing the usage patterns. The system will be able to control and monitor the different appliances in a house. The problem tackled in this report is the monitoring and control of the different appliances in a house and suggest actions to be taken. This project aims to develop an algorithmic model and to develop patterns of specific needs based on the usage of Smart Home Devices and to present it to the customers and to predict the usage patterns if it continues in a similar manner. The user usage data will be mapped into a graph and presented as a demographic for the user to see his/ her daily, monthly, yearly energy usage and suggests to take precautionary measures if there is any problems. The user is authenticated with the User ID and can look for usage patterns. The user will be able to completely automate his house and simultaneously monitor energy usage.

1. INTRODUCTION

As we all know that the population is being increasing throughout the world, so is the energy consumption. The rapid development in technology has made possible that almost every household electrical appliance can be monitored using technology. So there are some of the household electrical appliances that we use periodically which makes them to have some usage patterns.

So our project aims at automating these appliances by observing their power usage trend using some algorithms that will be running in the cloud. So we have a device called quad device through which electrical appliances should be connected to the socket. This quad device measures the power being drawn by the appliance and later uploads the sane data to the cloud. So the data in the cloud is fetched and is fed to the algorithms to check whether they have some usage pattern. Later a suggestion will be made to the user regarding this usage pattern if found. The below figure shows an example of arima model which is used to forecast future values based on the past data provided.

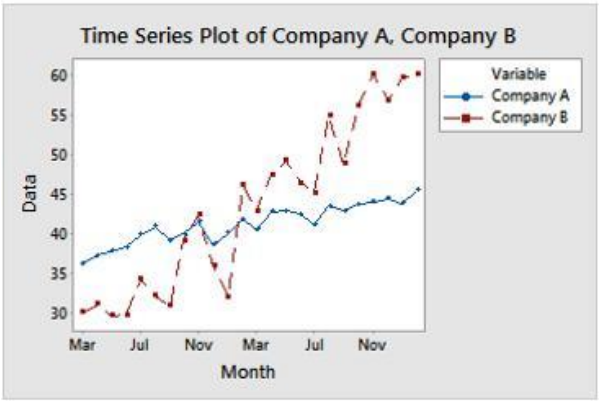

Figure 1.1: Time Series Plot of Company A ,Company B

2. RELATED WORK

Multiple academic articles have been written about analysing energy usage patterns using data analytics, one such article. The amount of household energy consumption accounts for a substantial proportion of total energy consumption worldwide. In some European and American countries, the percentage of household energy use in total energy consumption is approximately 30%. In China, the rapid development of economy, and society in the past decades has resulted in increasingly high energy demand, in which household energy consumption accounted for a significant proportion. It was reported that residential energy consumption accounted for about 11%, of China's total energy consumption in 2012.[10] As a result, household energy consumption has led to serious environmental problems. For instance, nearly 38% of the total US carbon emissions come from the direct energy use of households in the US. [11] Utilities can track their energy cost, but usually only at a high level and only after the fact by reviewing bills from a previous period. Using data integration and data analytics to calculate or estimate energy use down to the asset level could improve the understanding of how much energy is being used and how it relates to the

energy bill. Additionally, bit could provide Key Performance Indicator (KPI) metrics, such as energy and cost calculations, to show asset use and efficiency. Analytics also support decisions on how to balance energy consumption and production with real-time energy market prices

3. METHODOLGY

As we all know that the population has been increasing throughout the world, so is the energy consumption. The rapid development in technology has made it possible that almost every household electrical appliance can be monitored using technology. So there are some of the household electrical appliances that we use periodically which makes them to have some usage patterns.
The design of a project is where the key features of the project along with its structure are described. This project consists of only software requirements and there are no hardware components included in the design of this project, they are i) Backend Design ii) Frontend Design

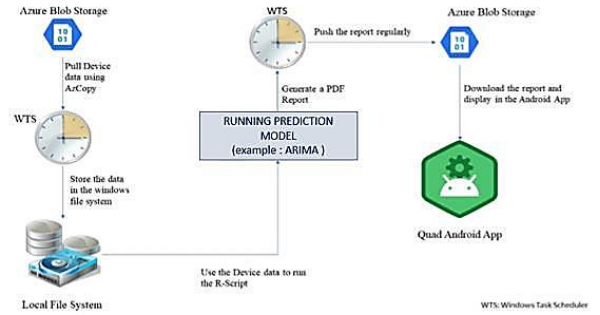

Figure 3.1 Architecture Diagram

3.1 Dataset Description

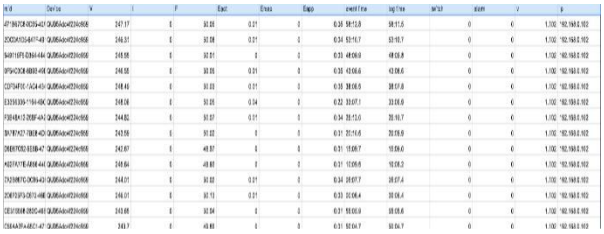

Figure 3.2: Dataset Downloaded from Azure Blob Storage

Dataset contains the data that has been pushed to the cloud by the IoT device. Dataset contains the following columns (Device Id, Voltage, Current , Power, Event Time, Switch State).

3.2 Data Analysis Process

There are various software platforms used which run on the cloud. The cloud service provider used here is Microsoft Azure services and we use the Azure Blob storage for storing and retrieving data from the cloud remotely. We also use the Windows Task Scheduler which is a software to schedule tasks, that are to be executed regularly. These tasks can be scheduled to run at a particular time of the day, everyday. The results of the execution are pushed to the cloud, simultaneously downloaded and displayed in the Android app.
As shown in the figure 3.1 the architecture design shows us how the data analysis process happens. First we download the data from azure blob storage and pass the data to the program that applies arima algorithm on the data passed and pass the predicted values to the azure blob storage, which will later be shown in android application.

3.3 ARIMA MODEL

Arima stands for Autoregressive Integrated Moving Average. An ARIMA model is a class that contains statistical models that helps in analysing data and enables time series forecasting. It explicitly caters to a suite of standard structures in time series data and in this way it provides a simple yet powerful way for time series forecasting. The main part of this arima model it just generalizes Auto Regressive moving average and adds a notion of integration to it that helps in time series forecasts.

The acronym itself is descriptive and key aspects of the model can be elaborated as follows

- AR: Auto regression. This is a model that uses dependent relationship between an observation and some number of lagged observations.
- I:Integrated. Differencing of raw observation(e.g. to keep time series stationary the current observation is subtracted from the observation at the previous time step)
- MA: Moving Average. This model uses the dependency between an observation and a residual error obtained from applying moving average model to a lagged observations.

Auto arima is used to select the best fit model that is suitable for the data supplied

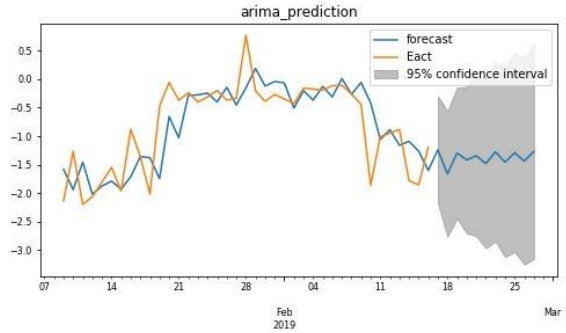

Figure 3.3 :Arima model graph

ARIMA model predicting the device's future usage based on its past observation.

4. AZURE STORAGE COMMUNICATION

Azure Blob storage is Microsoft's object storage solution for the cloud. Blob storage is optimized for storing massive amounts of unstructured data. Unstructured data is data that does not adhere to a particular kind of data model or definition, such as text or binary data. We have used azure blob storage to push data from the IoT Device and as required pull the data We use Azure CLI to pull data from Azure blob storage to windows file system. Install the Azure CLI onto the windows system using command prompt and use **Azcopy** to push and pull data remotely to the cloud. Using Azcopy is a very simple operation, we need to fetch the source endpoint from the azure blob storage account, also copy the secret key. Use both in the azcopy command and we can acquire the data anytime and anywhere. The Azcopy command is as mentioned

in the example below, to Push the files from local storage to Cloud below command is used
AzCopy /Source:C:\Users\azurefiles /Dest:https://xyz.blob.core.windows.net/blobname /DestKey: MP*******gjSVig==***
To pull the files from cloud to local storage below command is used
AzCopy /Source: ***https://xyz.blob.core.windows.net/blobname*** **/Dest:** ***C:\Users\azurefiles*** **/SourceKey:** ***MP**********gjSVig==***

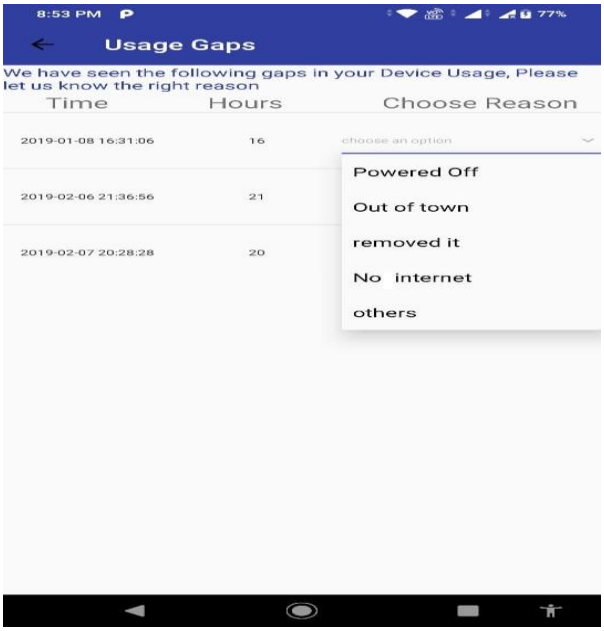

Figure 4.3: Android Application to report device usage gaps

Android application having an activity to provide the user to report the reason for device usage gap, in which the date at which the gap occurs is shown by the android application.

5. RESULTS & FINDINGS

- A graph will be displayed for better visualization of energy usage since a demographic graph is better understood than raw usage data.
- The user will be able to completely automate his house and simultaneously monitor energy usage.
- The Power management and household energy consumption will be monitored.
- Scheduling the devices and help automate the process of manually switching the device ON/OFF from anywhere daily.
- This solution also has the feature to generate a daily, weekly and monthly report showing the user's energy usage.
- Plan and schedule Electrical equipment based on date, time and duration.
- This project also adds a data analytics feature where we analyse any abnormalities in the voltage, rate the user's power usage, give a graphical representation of the same.
- Figure 5.1,5.2 are an example of the visual graphs presented to the user showing his/her everyday usage characteristics and voltage variations categorised as Danger/No Danger

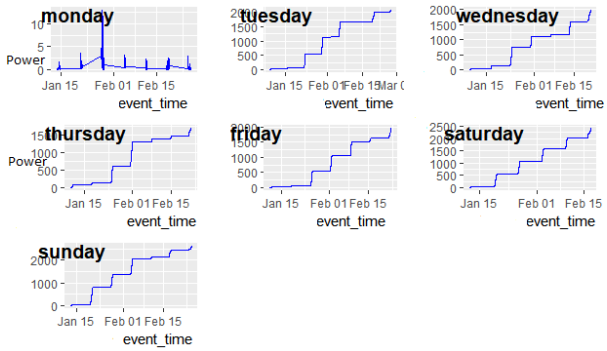

Figure 5.1 Everyday Analysis of power usage

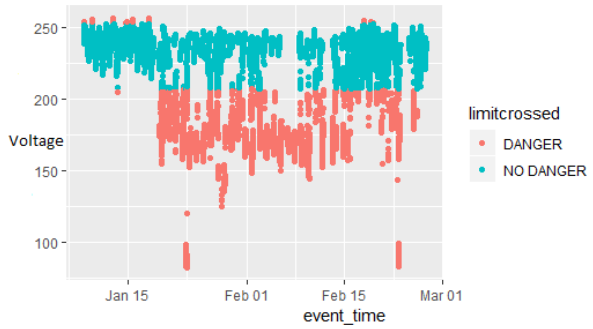

Figure 5.2 Voltage variation categorised as Danger/No Danger

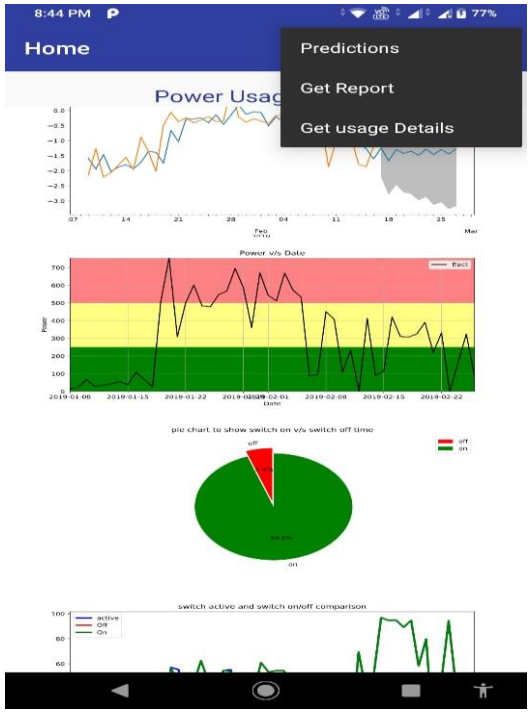

Figure 5.3 Report Displayed in the android app

6. CONCLUSION

The project is designed to produce energy usage patterns from users' data. The patterns produced in terms of graphs will give an insight to power consumption on daily, weekly basis. The report is sent to the cloud and thereby it can be downloaded by the authenticated user through the mobile application. The user can then take certain measures on power consumption accordingly.

Graph will be displayed for better visualization of energy usage since a demographic graph is better understood than raw usage data. The user can use this application for multiple purposes like, make a home theft proof by remotely monitoring his house for any uninformed power consumption, it can also be used as a circuit breaker if there are any multiple spikes in power supply and understand average energy consumption and suggest any alternatives (if necessary) to reduce consumption. The Power management and household energy consumption will be monitored. The user will be able to completely automate his house and simultaneously monitor energy usage.

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