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SMART METERING USING IOT AND AI

A Project Report of Capstone Project-2

Submitted by

SHUSHIL LAL DAS

(1613108003 / 16SCSE108003)

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Under the Supervision of

Mr. HIMANSHU SHARMA, M.Tech

Professor

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GALGOTIAS UNIVERSITY

SCHOOL OF COMPUTING AND SCIENCE AND ENGINEERING

BONAFIDE CERTIFICATE

Date: 18/05/2020

This is to certify that the dissertation entitled "**SMART METERING USING IOT AND AI**" by **Mr. SHUSHIL LAL DAS** student of **B.TECH** , of **GALGOTIAS UNIVERSITY, GREATER NOIDA,** is hereby accepted and approved as a credible work. It is further certified that this work has not been submitted for similar purpose anywhere else. His work has been found satisfactory for the partial fulfillment of the award of the degree of B.TECH.

SIGNATURE OF HEAD
Dr. MUNISH SHABARWAL,
PhD (Management),PhD (CS)
Professor & Dean,
School of Computing Science & Engineering

SIGNATURE OF SUPERVISOR
Mr. HIMANSHU SHARMA,
M.Tech
Professor
School of Computing Science & Engineering

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I here by declare that the project work entitled "**SMART METERING USING IOT and AI**" is an authenticated work carried out by **SHUSHIL LAL DAS**. Under the guidance of **Mr. HIMANSHU SHARMA** for the partial Fulfillment of the award of the degree of **B.TECH** and this work has not been submitted for similar purpose anywhere else except to **GALGOTIAS UNIVERSITY, GREATER NOIDA.**

SHUSHIL LAL DAS - 1613108003

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Signature:

Name: Shushil Lal Das

Roll No: 1613108003

Date: 15/05/2020

ABSTRACT

Using modern technologies of Internet of Things (IoT), Edge Computing, Over the Air (OTA) Programming, Serverless Computing, and Microservices Architecture, the project is aimed to achieve the required goals of fleet management, real time data analysis and seamless visualization. Using modern concept of server orchestration, it proposes to break all the barriers of traditional computing. From decrement in the bandwidth involved in data transmission to handling of any number of users at bulk, this project aim to build a comprehensive cloud solution with Amazon Web Services (AWS) platform integrated to a secured user application and a central dashboard. Also this project will be using Deep Learning algorithms like Recurrent Neural Network (RNN), in order to analyze the data incoming from numerous IoT enriched electric meters and provide wise notification tips to the consumers. The tips target in subtraction of unwanted energy consumption and addition of overall energy efficiency. Proper real time statistical and comparative analysis will be performed in the best manner as possible to revolutionize the entire energy ecosystem.

Keywords: Smart Energy Meter, Wi-Fi Module, Power Theft, Automatic Billing, Real Time Data Monitoring, GSM,

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ABBREVIATIONS

IOT: Internet of Things

RNN: Recurrent Neural Network

AWS: Amazon Web Service

OTA: Over The Air Programming

GSM: Global System of Mobile

WIFI: Wireless Fidelity

CSS: Cascading Style Sheets

JS: Java Script

HTML: Hyper-Text Markup Lanaguage

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CHAPTER-1

INTRODUCTION

1.1 Introduction of Conventional Meter

Energy is fundamental need of our life because of mechanical development and urbanization. Energy catastrophe is the main confronted by our society.One of the solutions is to control, analyze and reduce of electrical power consumption in households. Energy meter billing is an important part of energy distribution. Each time a person is needed from the authority to collect the reading of meter and create a bill to the consumer. But this created a problem because the manual reading needs manpower, time consuming and may cause an error. So, smart energy meter comes for providing the facilities of automatic reading of meter and also can detect the meter tempering by sending the message with the help of IOT. It also can detect the fault if occurs in the electric system overloading and warn the consumer of overload usage of electricity by sending the message.

Stealing of electricity is an issue, nowadays in energy meters, there is no proof of tempering of meters and are less accurate so it is not reliable more as the IOT based energy meter having the different features and saves the electricity from Thefting which is illegal and also protect from overloading of electricity to consumer. Automatic connection and disconnection can be done by passing a code such as a password from the board based on bill payment of consumer through IOT. Directing a fault in distributing system can be done by communicating between the distribution system and consumer energy meter. If there is a supply in the transformer and no supply in the consumer's end it means that there is a fault between consumer and distribution transformer. This transformer enables the electricity department to read the meter reading monthly without person visiting each home. This can be achieved by use of Arduino unit that continuously records the reading of energy meter, its non volatile

memory location. This system can also be used to disconnect the power supply of home when needed.

This paper mainly deals with smart energy meter, which utilizes features of the embedded system i.e. a combination of hardware and software. The paper discusses how and what type of work is done by IOT based smart energy meter. Also with the help of Wi-Fi Modem the consumer can monitor its consumed reading and can set threshold value through the webpage. If the consumer is not aware of threshold notification, then meter gets off automatically after that consumer can increment the threshold value and meter will automatically turn on.

Finally, the overall monthly bill with amount will be sent to the consumer as well as a service provider of text at first day of every month.

1.2 Introduction of Smart Meter

Smart meters are being incorporated into the grid to record and upload electrical and background data, with specially designed sensors and IoT-enabled devices. They are deployed in every electricity consumption unit and share their information with local control centers.It is an electronic device that records consumption of electric energy in intervals of an hour or less and communicates that information at least daily back to the utility for monitoring and billing.

Smart meters not only have two-way communication, but are equipped with real-time sensors that can gather the data on relevant factors, including frequencies used by different equipment and appliances.Traditional meters only measure the total consumption, providing no further breakdown of information; smart meters on the other hand measure site specific information, allowing utilities to introduce different prices for consumption based on usage during the time of day and according to the season.

Proponents believe that billing customers at a higher rate for peak times will encourage consumers to adjust their consumption habits to be more responsive to market prices and could delay the construction of additional generation, thereby controlling sharp rise in electricity prices. There are some concerns, however, that low income and vulnerable consumers may not benefit from intraday time-of-use tariffs; besides the inherent ability

of smart meters to provide two-way communication and data readings remotely could result in large layoffs of meter readers. The smart metering business case is broad and complex, as the technology has the potential to impact the entire electricity system, from generation investment and dispatch, through network optimisation, all the way to retail operations and beyond into the home. The most commonly pursued benefits, however, have tended to be focused on the retail area, particularly the core areas of meter reads and consumer service support. While the benefits are becoming well characterized in the retail area, it is clear that many of the potential benefits from distribution optimisation and capital efficiencies are commonly discounted or ignored.

"The benefit of any smart metering to a utility is that the utility gets a better view of the customer's usage of electricity by the customer. While, the benefit to a customer is that a customer can also get a better view of his usage, through the customer portal and thereby control the usage of electricity. The customer and the utility can work closely to implement multiple programs such as time of day billing, demand management programs etc.,

Therefore, a smart meter is an electronic device that records consumption of electric energy and communicates the information to the electricity supplier for monitoring and billing. Smart meters typically record energy hourly or more frequently, and report at least daily. Smart meters enable two-way communication between the meter and the central system. Such an advanced metering infrastructure (AMI) differs from automatic meter reading (AMR) in that it enables two-way communication between the meter and the supplier. Communications from the meter to the network may be wireless, or via fixed wired connections such as power line carrier (PLC). Wireless communication options in common use include cellular communications (which can be expensive), Wi-Fi (readily available).

1.3 Present Scenario of Traditional Metering System

The present system of energy metering as well as billing in India uses electro-mechanical and somewhere digital energy meter which consumes more time and labour. The present system only provides feedback to the customer at the end of the month. Also the meter readings are taken manually. Consumer can know the units consumed by seeing their electricity bill only. Also huge manpower is required to take

the readings. There is no protection for energy meter tampering. The consumers cannot monitor the everyday energy consumption or usage. The major drawback of this system is the management of power consumption is difficult. Traditional meters only measure the total consumption, providing no further breakdown of information.

1.4 Objectives

The main objective of this project is to design and build a functional Smart Meter through software implementation, which is to be overlaid on the existing traditional perimeter infrastructure.

Following are some of the typical objectives of Smart Meter:

- To modify the traditional way of metering into smart things by providing it exclusive identification with sensors and devices that can communicate and share information through the web
- To analyze and control the electrical devices at whatever time from any part of the world
- To enable two-way communication between the meter and the central system
- To provide the information of when the energy was consumed
- To help consumers better manage their energy purchases
- To provide detailed and accurate analytics on electrical usage in real-time or at predetermined intervals
- To analyze the data incoming from numerous IoT enriched electric meters
- To provide wise notification tips to the user

- To enable the consumer to pay its electricity bills through online payment system

- A service provider can engage its consumer through some real time usage statistics, comparisons and tips for wise utilization through the consumer portal

- To awaken the consumers to safeguard themselves from unsecured usages

1.5 Scope of Smart Metering

In this modern period of Internet of Things, a physical world such as machines and sensors can be interfaced through the web.The things or items can be modified into smart things by providing it exclusive identification.

All in all,the primary scope is to implement IoT and AI based Smart meter that not only enhance the ease with which electricity bills are generated and transmitted, they also provide better control on one's electricity consumption by providing real time consumption data. The consumer can monitor his/her electricity usage and in turn optimize his/her consumption.

A smart metering using IoT and AI also offers insights into the expenditure on electricity which proves to be a great incentive for consumers to save electricity and in turn reduce the pressure on the constantly depleting non-renewable sources of energy.

A network of all the smart metering using IoT and AI connected to a smart grid will positively influence the methods and modes of electricity generation, transmission and distribution.

The aim to allow power companies that could only guess what kind of usage was happening in a particular area, based on the data from the sub-stations supplying power to that section of the grid to know all the data of a particular household too.

CHAPTER-2

LITERATURE SURVEY

2.1 Literature Review by Scientist

Paraskevakos was awarded a U.S. patent in 1974[1] for developing the concept of smart meter and in 1977, he launched Metretek, Inc.,[2] which developed and produced the first smart meters.[3] .This system was developed pre-Internet, Metretek utilized the IBM series 1 mini-computer[4]. In 1972, Theodore Paraskevakos, while working with Boeing in Huntsville, Alabama, developed a sensor monitoring system that used digital transmission for security, fire, and medical alarm systems as well as meter reading capabilities. This technology was a spin-off from the automatic telephone line identification system, now known as Caller ID.

According to Indian Times which was published in 13 August 2019[5], Energy Efficiency Services Ltd (EESL) has successfully installed over 5 lakh smart meters in Uttar Pradesh, Delhi, Haryana, Bihar and Andhra Pradesh, under Smart Meter National Programme (SMNP) that will enhance consumer convenience and rationalise power consumption in India.The Smart Meter National Programme aims to retrofit 25 crore conventional meters with smart variants leading to 80-100 per cent improvement in billing efficiency. While in the United Kingdom the large energy suppliers were operating over 400,000 smart gas and electricity meters, representing 0.9 percent of all the domestic meters operated by the large suppliers in 2014[6].

According to a paper titled "ARM-based energy management system using smart meter and Web server"[7],prepared by "carmine Landi, Pietro Merola, Giacomo Lanniello"in 2011,a low cost ARM-based energy management system was designed. It is a part of distributed system that measures the main power system quantities and collect the statistics of power consumption and power quality which is able to interface devices

for load movement. The device easily access the information and local access the combination of a smart meter and data communication. Similarly, according to the paper titled 'An Approach to Automate Power Meter Reading & Billing System'(2013)[8], it proposed a solution to implement Automated Power Meter Reading & Billing System for bringing smart governance in power/energy supply departments by the use of GPRS/IP, Server based remote meter reading and billing algorithms to automate the reading and billing process, nTier Architectures based Model that approach provides real time energy which leaded to more throughput in power/energy management.

In 2014[9], an approach to implement smart meter using image processing was made. It described a prototype for Automatic Meter Reading (AMR) system that uses a Traditional meter, Zig-Bee modules, and a serial camera unit. This camera will take the photo of meter reading and transmit it to the server PC through Zig-Bee, where that image undergoes segmentation, recognition process and reading get separated which would be further used for preparing bill. While in 2015[10], the GSM and Zibee based Automatic Energy Meter Reading System with Instant Billing was implemented using Cortex-M3 LPC1768 as important processor to do communication in short distance and SIM900 to achieve communication function in long distance, using RS-232 link communication joint to connect the communication between Zigbee and GSM technology. This system has many significant excellences , such as wireless, low cost, a little power consumption, great quantity of data transmission , while it has great extension & security.

With the paper published in 2016 titled 'Privacy-friendly Forecasting for the Smart Grid using Homomorphic Encryption and the Group Method of Data Handling'[11], it concerned with enhancing the privacy of the smart meter readings in the setting of forecast prediction. In this paper , the author showed the method to compute the forecast prediction such that the supplier does not learn any individual consumer usage information by using the Fan-Vercauteren some what homomorphic encryption scheme, typical prediction algorithms based on artificial neural networks that require the computation of an activation function, show that Ivakhnenko's group method of data handling would be suitable for homomorphic computation.

On September 2017, the authors “Mrs Sandhya Shinde, Mr.Yogesh Yadav,Miss. Bharti Sontakke,Miss. Pratiksha Zapake” presented a paper titled “IoT Based Smart Energy Meter”[12]in which smart meter was designed based on a Arduino and implementation of energy meter using IoT concept.The Arduino checks the main meter and sub meter reading to check the theft status. It provides the consumers to track their energy consumption. It allows the supplier to take control over the consumers and can disconnect the connection if a consumer fails to pay bill.

In 2018, the authors named “Amrita Singh, Ravi Gupta” presented a paper titled “Iot based smart energy meter”[13] in which the traditional meter was replaced by a metering module which consists metering IC and micro controller that scans the energy meter automatically after every month and transmit to the consumer and propose service provider system. The meter gets off automatically if the threshold value of consumption provided by consumers on their webpage is crossed.

In 2018, a research article was published by the authors “R.Asha, R.Aruna, J.Divya, K.Balasaranya” titled “Smart Energy Meter for Advanced Metering and Billing Alert Framework”[14] in which Evolutionary Algorithms(EAs) (Binary Particle Swarm Optimization (BPSO), Genetic Algorithm (GA) and Cuckoo search) based DSM model for scheduling the appliances of residential users was presented to optimally consume grid and renewable energy sources. It was purposed significantly to reduce the electricity bill and high peaks.

CHAPTER-3

PROBLEM STATEMENT

Traditionally, the electricity meters are installed on consumer's premises and the consumption information is collected by meter-readers on their fortnightly or monthly visits to the premises. This method of gauging electricity consumption has the following disadvantages:

3.1 Connectivity

In India, the current electricity billing system is completely manual. The electric meters are situated in the houses, offices and factories etc. The energy meter reading is collected by meter readers on their fortnightly or monthly visits to the premises. This system has disadvantage of appointing meter reader to take the meter reading, effects consumer privacy etc. In this direction this project undertakes the meter reading without human intervention.

There is no connectivity between consumer and the electricity meter or in control centers ,the electricity provider company. In traditional meter, we are not able to know the present electricity data usage and their cost. While with the help of smart metering, the customer can connect by the GSM module and wifi support through the mobile application, and also the control center connect through your smart meter app, they can see your consumption and then your activity through desktop application.

3.2 Control

As seen in Developing country, electro mechanical meter reading systems is present in premises of consumers and information is collected by using man power in each month. So, that meter has some disadvantages like:Meter reader person must be required to read that meter of each consumer for reading power consumption. By using of electromechanical meters meter reading changes and errors are more.For the United Kingdom, any installed electricity meter is required to accurately record the consumed energy, but it is permitted to under-read by 3.5%, or over-read by 2.5% [33].Calculated

bill is used at time when extreme weather conditions occur and meters to be read are not easily accessible to the reading -so it is problematic for consumer and supplier.

Therefore, we don’t have any control over the usage of total electricity as the bill is generated at the end of the month and the consumer don’t have data about power consumption.Suppose when you consume 200 unit but you have bill payment of 500 unit . Since due to lack of data and control ,the consumer cannot impose any action against this type of fraud. Since, smart metering helps to know and control your electricity by the application to check your current data and bill.There is evidence of your power consumption.

3.3 Data analysis

In traditional electricity meter,there is no data storage.If access cannot be gained to the meter, this may result in estimated bills. Electricity use is tracked by either waiting for customer's monthly or quarterly bill or manually reading customer's household meter by oneself. There is no outage detection, as distribution companies cannot react quickly to interruptions in the supply and connections and disconnections must be done manually.

While smart meters helps in data storage, stores electricity consumed every half of an hour, data is automatically transmitted to the metering company, digital data of energy consumption and TOU are provided in near real time, Automated outage detection enable distribution companies to restore power quicker than traditional electricity metering, connections and disconnections are faster, because they are managed remotely. Traditional electricity meters only show the quantity of electricity consumed since meter reader last read the meter.

Therefore, in traditional electric meter we only get the data of the of the consumer on the monthly basis and cannot get the data based on the daily usage of the consumer.

3.4 Security

Theft of electricity is a criminal practice by stealing electric power. It is considered as a crime and liable for punishment by heavy fines and in some cases jail. The basic method of stealing electricity is direct hooking from line-Hooking(catching) is the

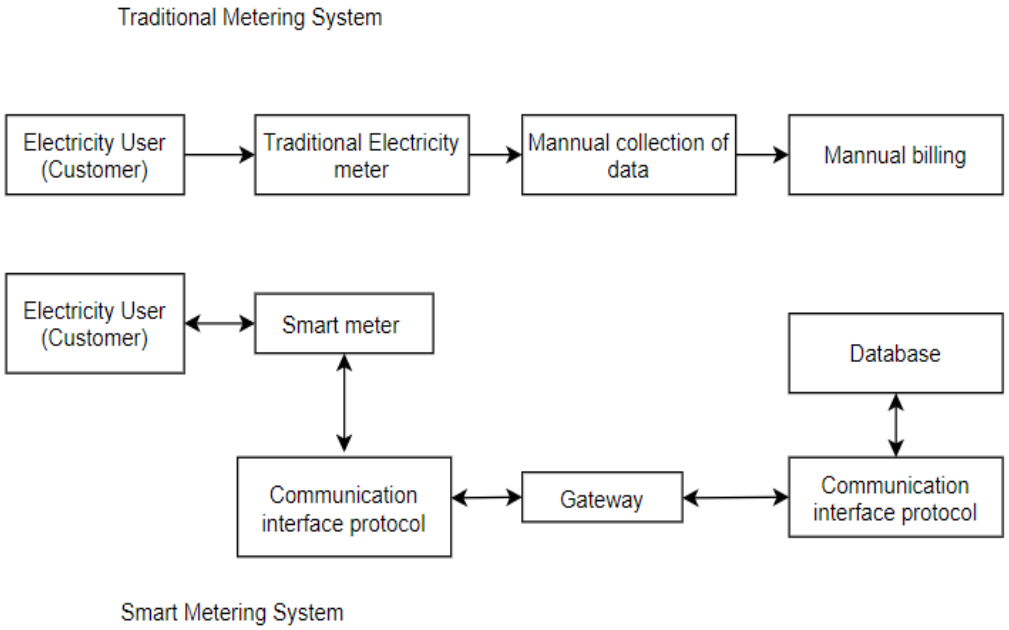

Fig 1.1- Difference in Traditional Metering System and Smart Metering System

most used method. 80% of global power theft is by direct tapping from the line. The consumer taps into a power line from a point ahead of the energy meter. This energy consumption is unmeasured and obtained with or without switches.

The various other methods of electrical power theft are:

3.4.1 Bypassing the energy meter

In this method the input terminal and output terminal of energy meter is short circuited preventing the energy from registration in energy meter.

3.4.2 Injecting foreign element into the energy meter

Meters are manipulated via remote by installing a circuit inside the meter so that the meter can be slowed down anytime. This kind of modification can avoid external inspection attempts because the meter is always correct unless the remote is turned on.

3.4.3 Physical obstruction

This type of interfering is done to electromechanical meters with the rotating element. Foreign material is place inside the meter to obstruct the free moment of the disc. Lower rotating desk signals less energy consumption.

3.4.5 ESD attack on electronic meter

This type of interfering is done on electronic meter to make either temporary damage or permanent damage.

3.4.6 Reversing the dials of meter

This is the commonly used method in which the meter is open itself without damaging it's seal and reversing the dial which might be complicated and required expert skills

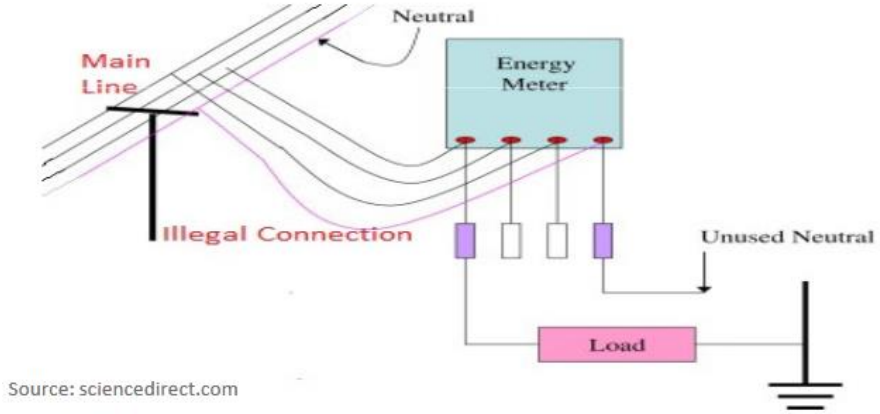

Fig 1.2- Energy Theft

CHAPTER-4

PURPOSED MODEL

In this project an integrated Internet of Things architecture for smart meter networks are proposed. It discusses the communication protocol, the data format, the data gathering procedure, and the decision system based on big data treatment. Real measurements show the benefits of the proposed IoT architecture for both the customers and the utilities. In this model, the traditional meter is reused and redesigned which is embedded with CT, VT, thermositor and other sensor for self performance.

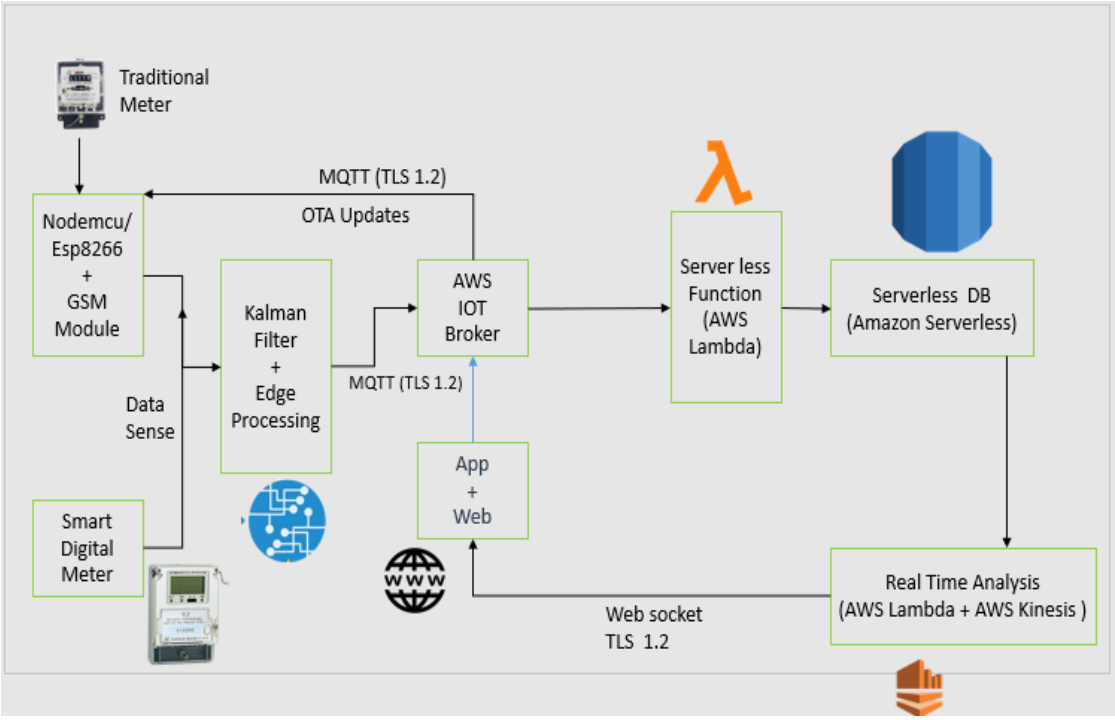

Fig 1.3- Traditional Meter to Smart Digital Meter

Traditional meter is embedded NodeMCU/ESP8266 and GSM Module. The followings are discussed below:

4.1 NodeMCU/ESP8266

- It is a low-cost open source IoT platform
- **NodeMCU** is an open-source firmware and development kit that helps you to prototype or build IoT products. It includes firmware that runs on the **ESP8266** Wi-Fi SoC from Espressif Systems(local and remote control of **Wi-Fi** devices including smart lights and **smart plugs**), and hardware which is based on the ESP-12 module.
- The name "NodeMCU" combines "node" and "MCU" (micro-controller unit)
- A **microcontroller** (MCU for **microcontroller unit**) is a small computer on a single metal-oxide-semiconductor (MOS) integrated circuit chip.
- NodeMCU supports the **MQTT IoT protocol.**

4.2 GSM Module

- A **GSM module(**Global System for Mobile Communications, originally Groupe Spécial Mobile**)** is a chip or circuit that will be used to establish communication between a mobile device or a computing machine and a **GSM** system.
- GSM modem is specialized type of modem which accepts a sim card, and operates over a subscription to a mobile operator. just like a mobile phone.
- When a GSM modem is connected to a computer, this allows the computer to use the gsm modem to communicate over the mobile network.
- While these GSM modem are most frequently used to provide mobile internet connectivity. many of them can also be used for sending and receiving messages.

It’s functions include:

- Read, write and delete SMS messages.
- Send SMS messages.
- Monitor the signal strength.
- Monitor the charging status and charge level of the battery.
- Read, write and search phone book entries.

Smart meter using AI and IoT uses GSM module to build connection between consumers and producers. The consumers get the notifications regarding their power consumption statistics and different wise tips for controlling energy consumption.

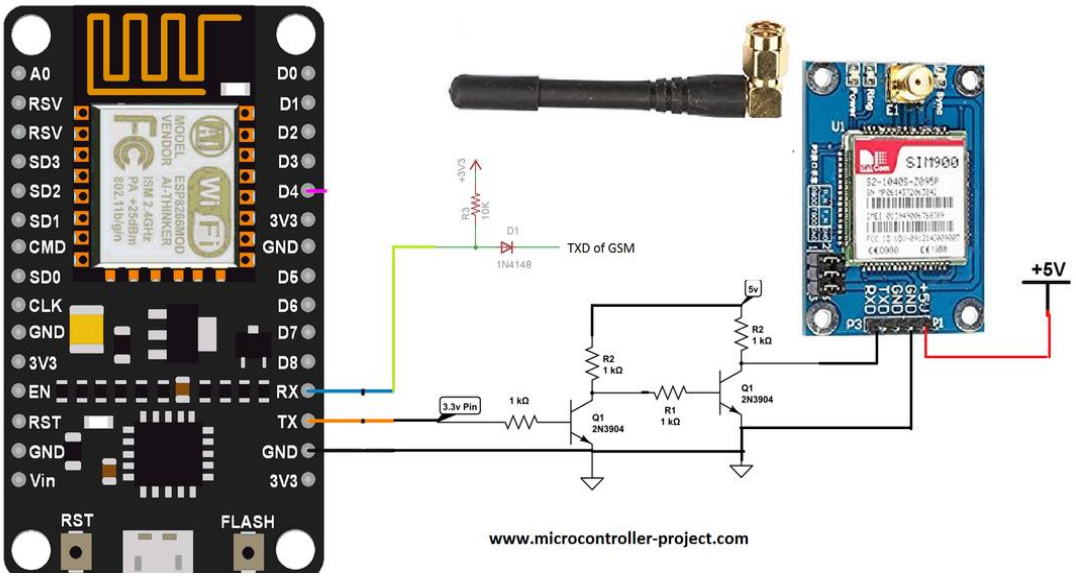

Fig 1.4- Sim900 GSM interfacing with nodemcu wifi module

4.3 Kalman filter

The **Kalman filter** is an efficient recursive **filter** that estimates the internal state of a linear dynamic system from a series of noisy measurements. It is used in real-time Global Positioning System (GPS). Kalman filter consists of two distinct processes, namely, the prediction process and the measurement process. Both processes are combined and operated in a recursive manner to achieve optimal Kalman filtering process.

In traditional power system studies, power system state can be estimated by combining Kalman filters with a hypothetically "true model and available measurements. In the ideal case, the hypothetical system model has accurate noise statistical characteristics incorporated into it. However,in reality, noise statistics can never be really known

exactly. Apart from errors arising in the modeling phase, the measurements are also riddled with errors due to device failure or even worse, malicious data attacks. To facilitate illegal activities like energy theft, attachers construct bad data which evades bad data detection mechanisms in power systems. This can have devastating effects like false dispatch in the distribution process and device breakdown during power generation .

This filter identifies -device failures, unusual disturbances, and malicious data attacks . Kalman Filter is a dynamic state estimation method which is mainly used in this paper for noise variation estimation.

The Kalman filter is an advanced type of filter which is used to filter the measurement noise and provide the optimal estimation of a dynamic system's state. It is recursive in nature so that new measurements can be processed as they arrive. Kalman filter minimizes the MSE (Mean square error) of estimated parameters. An Extended Kalman Filter,based on Taylor series expansion around a nominal va l u e which is taken as the previous estimate in this case needs to be designed. The state transition matrix F is given by the Jacobian vector function ,about state and the noise scaling matrix τ is given by the Jacobian vector function (,)about state w. Since the process dynamics are continuous while the measurements are usually discrete in nature, a hybrid continuous-discrete EKF model is developed. The EKF equations of discrete time cannot be used directly and thus continuous time EKF equations have to be derived. Also, since the measurements are discrete in nature, a hybrid of both is developed and described below(repetitive data).An observable, non-linear dynamical system, with the continuous process dynamics and discrete measurement of dynamics is explained by:Here $\in\Re$shows the n-dimensional state vector of the system, f (.) Dx $\rightarrow\Re$n is a finite non-linear mapping of system states to system inputs, z$\in\subset\Re$denotes the p-dimensional system measurement, h(.) :$\subset\Re\rightarrow\Re$is a non-linear mapping of system states to output, $\in\Re$denotes the continuous process noise scaling matrix ,$\in\subset\Re$denotes the w-dimensional random process noise and $\in\subset\Re$denotes the v-dimensional random measurement noise.

4.4 Edge processing

Edge processing refers to the execution of aggregation, data manipulation, bandwidth reduction and other logic directly on an IoT sensor or device. The idea is to put basic computation as close as possible to the physical system, making the IoT device as "smart" as possible.

The functions of edge processing used in Smart Metering using AI and IoT:

- Processing data at the edge
- Sending final results to cloud
- Mitigates unwanted cloud processing
- Run asynchronously in background
- Reduce cloud cost
- Decrease load on network

4.5 MQTT IoT Protocol

MQTT stands for Messaging Query Telemetry Transport. It is a publish/subscribe, extremely simple and lightweight messaging protocol, designed for constrained devices and low-bandwidth, high-latency or unreliable networks. The design principles are to minimize network bandwidth and device resource requirements whilst also attempting to ensure reliability and some degree of assurance of delivery. These principles also turn out to make the protocol ideal of the emerging "machine-to-machine" (M2M) or "Internet of Things" world of connected devices, and for mobile applications where bandwidth and battery power are at a premium.

TLS 1.2 uses a combination of symmetric and asymmetric cryptography, as this provides a good compromise between performance and security when transmitting data securely.The session key is then used for encrypting the data transmitted by one party, and for decrypting the data received at the other end.

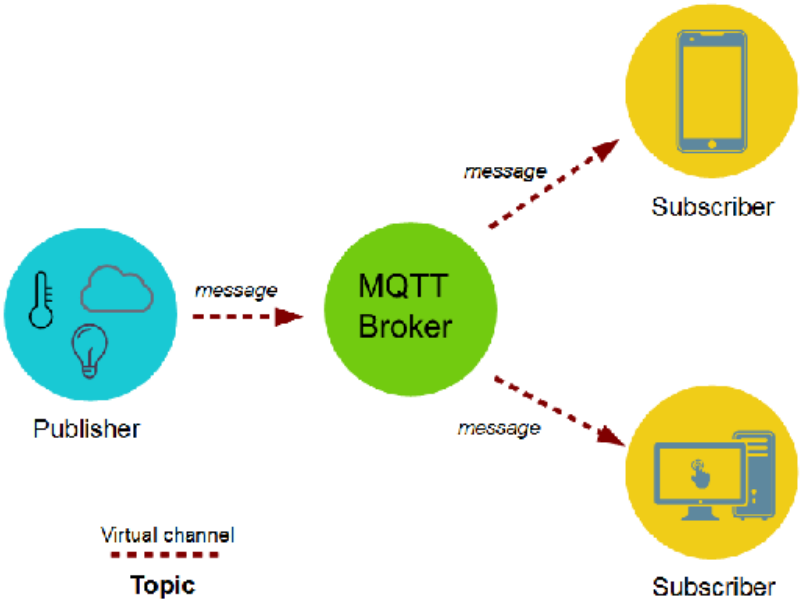

Fig 1.5- MQTT Broker

4.6 AWS IOT BROKER

The AWS IoT message broker implementation is based on MQTT version 3.1.1, but it deviates from the specification as follows:

- AWS IoT Core supports MQTT Quality of Service (QoS) levels 0 and 1 only. AWS IoT Core does not support publishing or subscribing with QoS level 2. When QoS level 2 is requested, the AWS IoT message broker does not send a PUBACK or SUBACK.
- In AWS IoT Core, subscribing to a topic with QoS level 0 means a message is delivered zero or more times. A message might be delivered more than once. Messages delivered more than once might be sent with a different packet ID. In these cases, the DUP flag is not set.
- When responding to a connection request, the message broker sends a CONNACK message. This message contains a flag to indicate if the connection is resuming a previous session.

- When a client subscribes to a topic, there might be a delay between the time the message broker sends a SUBACK and the time the client starts receiving new matching messages.
- The MQTT specification provides a provision for the publisher to request that the broker retain the last message sent to a topic and send it to all future topic subscribers. AWS IoT Core does not support retained messages. If a request is made to retain messages, the connection is disconnected.
- The message broker uses the client ID to identify each client. The client ID is passed in from the client to the message broker as part of the MQTT payload. Two clients with the same client ID cannot be connected concurrently to the message broker. When a client connects to the message broker using a client ID that another client is using, the new client connection is accepted and the previously connected client is disconnected.
- On rare occasions, the message broker might resend the same logical PUBLISH message with a different packet ID.
- The message broker does not guarantee the order in which messages and ACK are received.

The following functions of MQTT protocol are used in Smart Metering using AI and IoT:

- Messaging Query Telemetry Transport
- Pub/Sub Model
- 93X faster throughput
- 8X less network overhead
- Better for fleet management
- TLS 1.2 Encryption Security

In a pub/sub model, any message published to a topic is immediately received by all of the subscribers to the topic. Pub/sub messaging can be used to enable event-driven architectures, or to decouple applications in order to increase performance, reliability and scalibility.

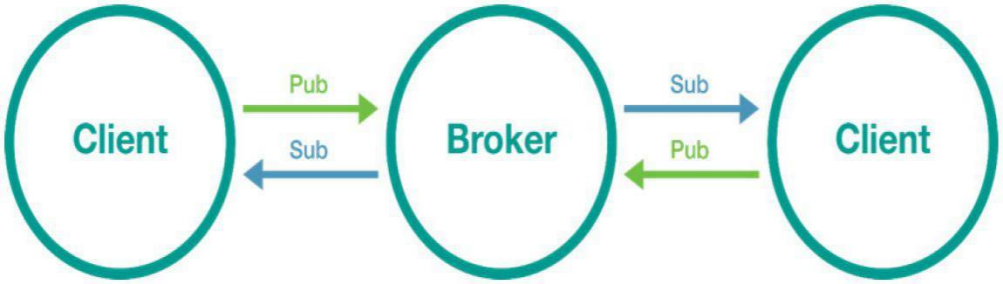

Fig 1.6- AWS IoT Broker

4.7 Aws Lamda

AWS Lambda is a serverless computer service that runs your code in response to events and automatically manages the underlying compute resources for you. You can use AWS Lambda to extend other AWS services with custom logic, or create your own back-end services that operate at AWS scale, performance, and security. AWS Lambda can automatically run code in response to multiple events, such as HTTP requests via Amazon API Gateway, modifications to objects in Amazon S3 buckets, table updates in Amazon DynamoDB, and state transitions in AWS Step Functions.

Lambda runs your code on high-availability compute infrastructure and performs all the administration of the compute resources, including server and operating system maintenance, capacity provisioning and automatic scaling, code and security patch deployment, and code monitoring and logging. All you need to do is supply the code.
The code you run on AWS Lambda is called a "Lambda function." After you create your Lambda function it is always ready to run as soon as it is triggered, similar to a formula in a spreadsheet. Each function includes your code as well as some associated configuration information, including the function name and resource requirements. Lambda functions are "stateless," with no affinity to the underlying infrastructure, so that Lambda can rapidly launch as many copies of the function as needed to scale to the rate of incoming events.

After you upload your code to AWS Lambda, you can associate your function with specific AWS resources (e.g. a particular Amazon S3 bucket, Amazon DynamoDB table, Amazon Kinesis stream, or Amazon SNS notification). Then, when the resource

changes, Lambda will execute your function and manage the compute resources as needed in order to keep up with incoming requests. The followings are the functions:

1. No servers to manage

AWS Lambda automatically runs your code without requiring you to provision or manage servers. Just write the code and upload it to Lambda.

2. Continuous scaling

AWS Lambda automatically scales your application by running code in response to each trigger. Your code runs in parallel and processes each trigger individually, scaling precisely with the size of the workload.

3. Sub second metering

With AWS Lambda, you are charged for every 100ms your code executes and the number of times your code is triggered. You pay only for the compute time you consume.

4. Consistent performance

With AWS Lambda, you can optimize your code execution time by choosing the right memory size for your function. You can also enable Provisioned Concurrency to keep your functions initialized and hyper-ready to respond within double digit milliseconds.

4.8 Amazon Kinesis

Amazon Kinesis makes it easy to collect, process, and analyze real-time, streaming data so you can get timely insights and react quickly to new information. Amazon Kinesis offers key capabilities to cost-effectively process streaming data at any scale, along with the flexibility to choose the tools that best suit the requirements of your application. With Amazon Kinesis, you can ingest real-time data such as video, audio, application logs, website clickstreams, and IoT telemetry data for machine learning, analytics, and other applications. Amazon Kinesis enables you to process and analyze

data as it arrives and respond instantly instead of having to wait until all your data is collected before the processing can begin.

Benefits:-

1. Real-time

Amazon Kinesis enables you to ingest, buffer, and process streaming data in real-time, so you can derive insights in seconds or minutes instead of hours or days.

2. Fully managed

Amazon Kinesis is fully managed and runs your streaming applications without requiring you to manage any infrastructure.

3. Scalable

Amazon Kinesis can handle any amount of streaming data and process data from hundreds of thousands of sources with very low latencies.

4. OTA updates

An over-the-air update is the wireless delivery of new software or data to mobile devices. Wireless carriers and original equipment manufacturers (OEMs) typically use over-the-air (OTA) updates to deploy firmware and configure phones for use on their networks. The initialization of a newly purchased phone, for example, requires an over-the-air update. With the rise of smartphones, tablets and internet of things (IoT) devices, carriers and manufacturers have also turned to over-the-air updates for deploying new operating systems (OSes) to these devices.

OTA technology has increased in significance, as mobile devices evolve and applications emerge. Mobile operators and telecommunication third parties can send OTA updates through SMS to configure data updates in SIM cards; distribute system updates; or access services, such as wireless access protocol (WAP) or multimedia messaging service (MMS). OTA updates also enable mobile operators to activate user subscriptions. OEMs can use OTA updates to fix bugs through firmware and change the user interface.

CHAPTER-5

SOFTWARE ENVIRONMENT

5.1 Software Used

Our product-service system shall have hierarchical order of monitoring system. For this purpose, we shall have admin management website for high level official in the entire city which will be embedded with IOT based Smart Metering for monitoring real time electricity consuming through graphically represented in mobile application through consumer login and registered and check their real time data consuming.

The technical frameworks, we use are NodeJS for server hosting, Python for machine learning and AI algorithms along with web front end languages like HTML, CSS, Bootstrap, Javascript & JQuery for the system.
Similarly, the database used under our system is MongoDB (NoSQL). In the same manner the feature of IoT is obtained using Raspberry Pi coded with python having relay connected to its output pin(s). And create react app for the implementation of the system.

5.2 Working of Create react app

This project was bootstrapped with Create React App.

Available Scripts

In the project directory, you can run:

yarn start

Runs the app in the development mode.

Open http://localhost:3000 to view it in the browser.

The page will reload if you make edits.

You will also see any lint errors in the console.

yarn test

Launches the test runner in the interactive watch mode.

See the section about running tests for more information.

yarn build

Builds the app for production to the build folder.

It correctly bundles React in production mode and optimizes the build for the best performance.

The build is minified and the filenames include the hashes.

Your app is ready to be deployed!

CHAPTER-6

OUTPUT

6.1 Mobile login screen

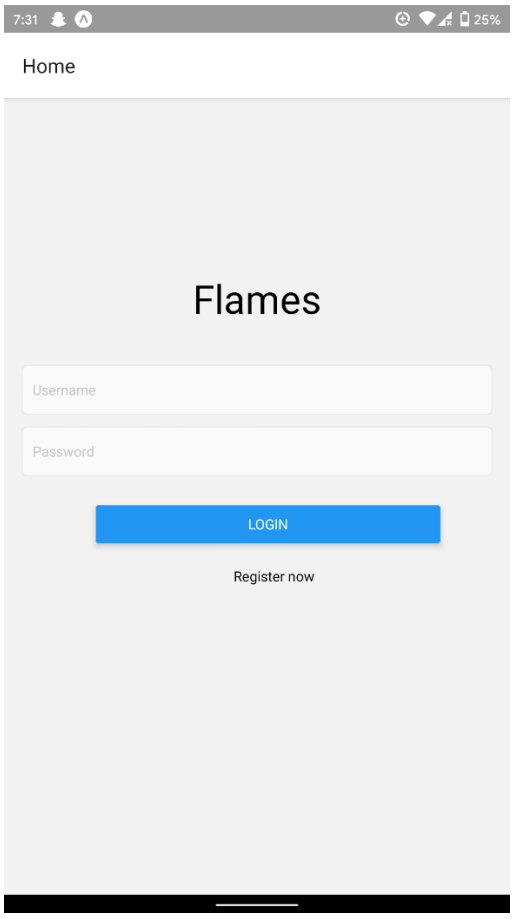

Fig 1.7- Mobile Login Screen

6.2 Mobile Registration Screen

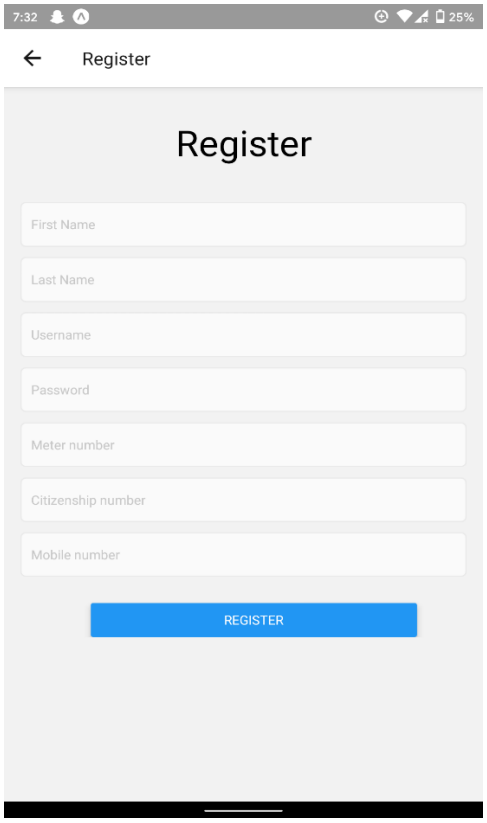

Fig 1.8- Mobile Registration Screen

6.3 Data Analysis of Cost Diagram and Data Diagram

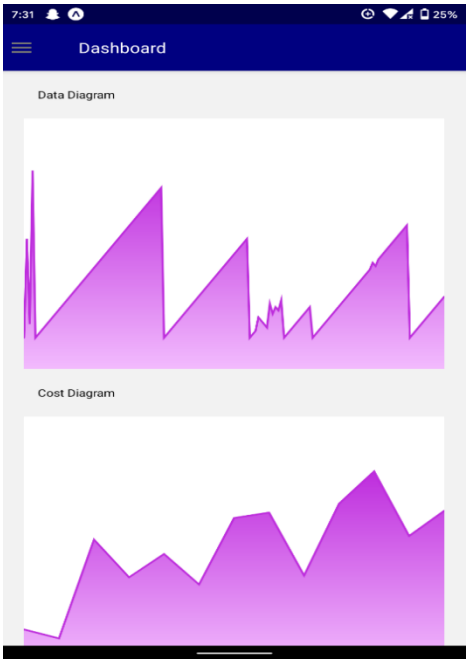

Fig 1.9- Cost Diagram and Data Diagram

6.4 Desktop Project

6.4.1 Admin Login Page

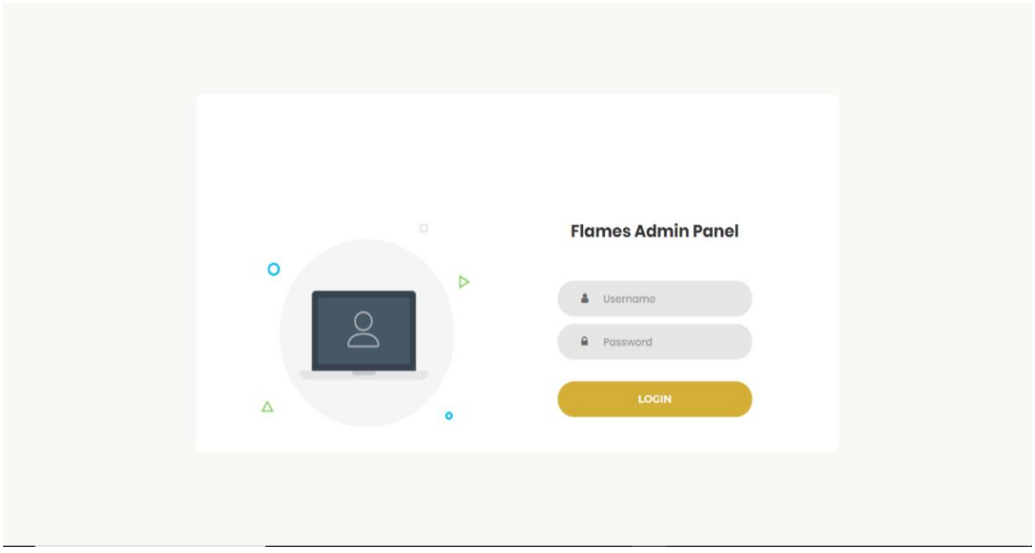

Fig 1.10- Flames Admin Panel

6.4.2 Energy meters location

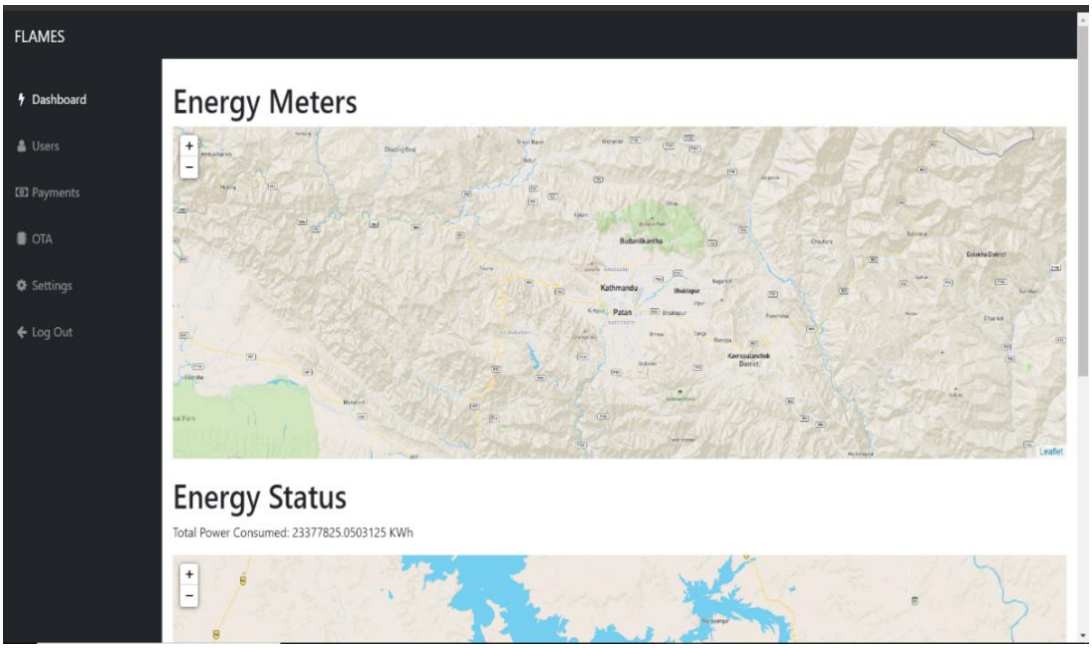

Fig 1.11- Energy meter Location

6.4.3 User Details

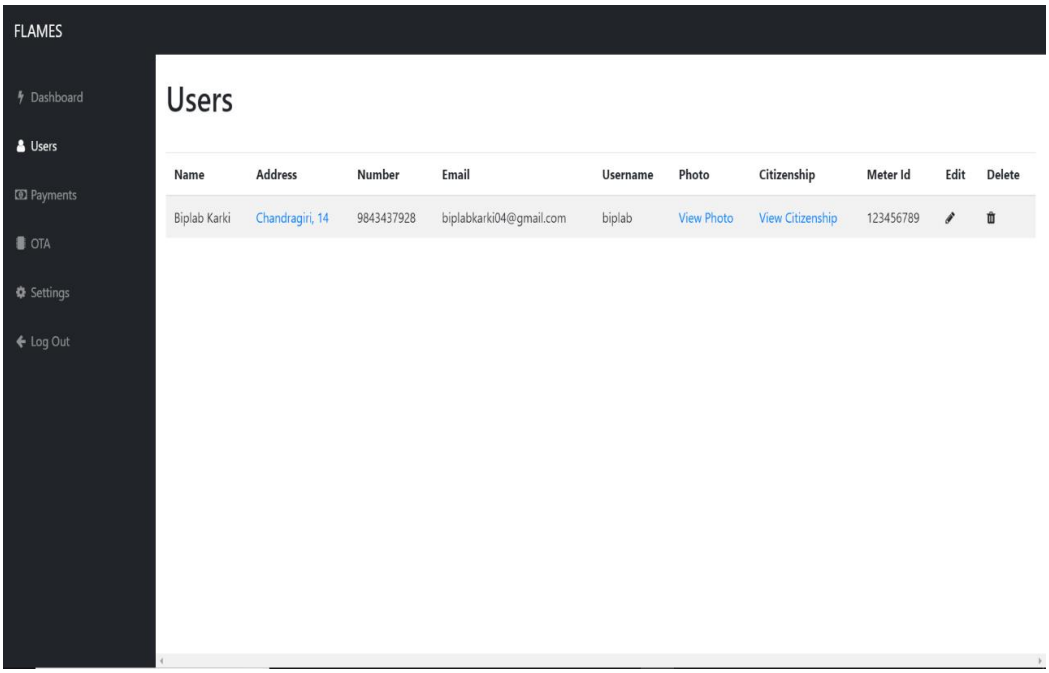

Fig 1.12- User Details

6.4.4 Payments of the User

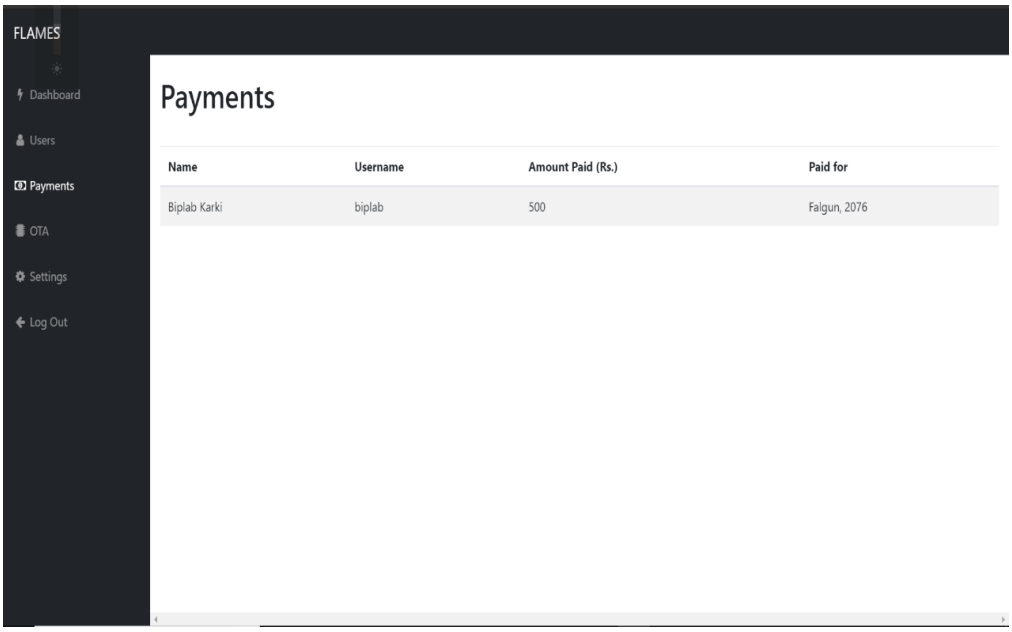

Fig 1.13- Payments of the user

CHAPTER-7

TESTING

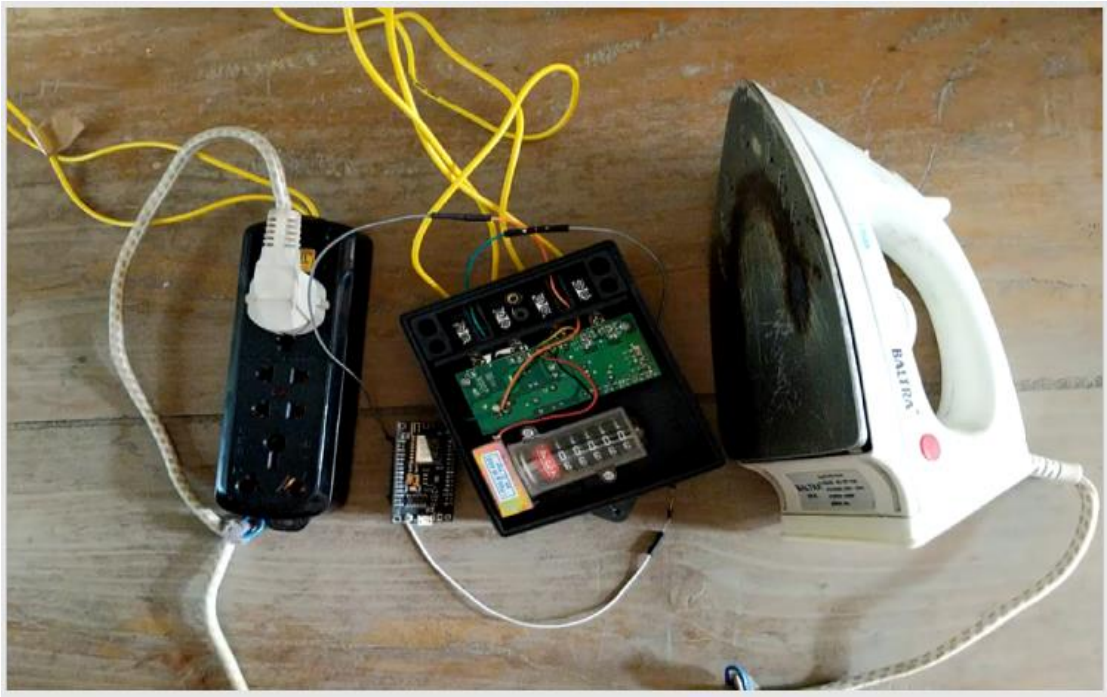

Fig 1.14- Testing of Smart Meter using AI and IoT

CHAPTER-8

BUSINESS MODEL

8.1 Business Analysis

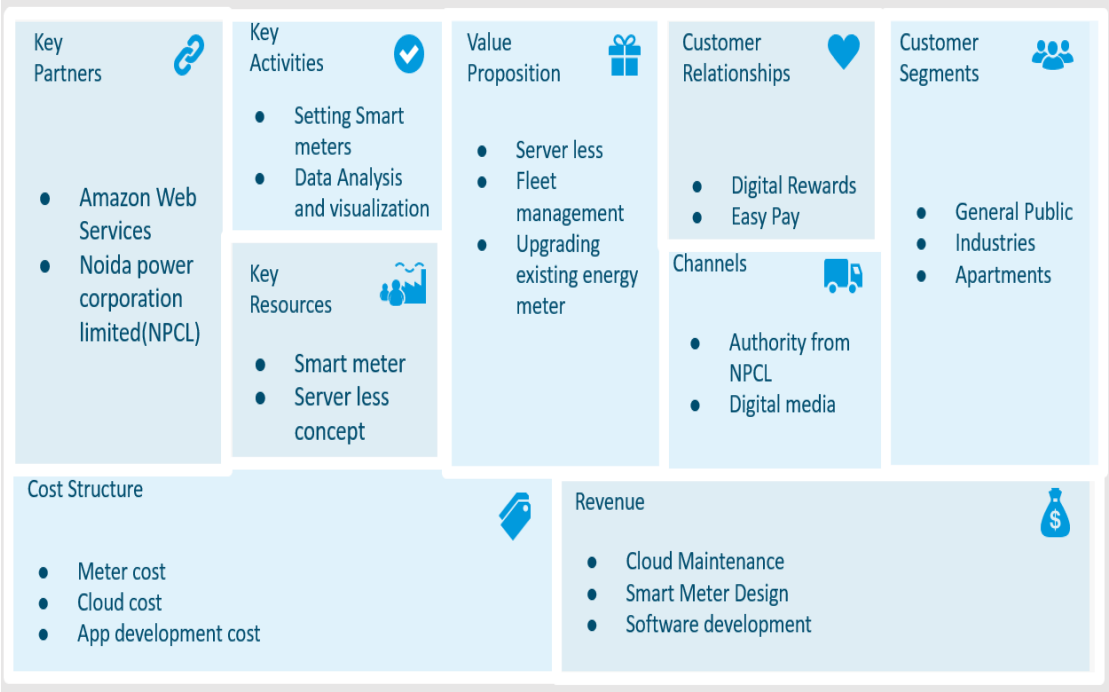

Fig 1.15- Business Model of Smart Meter Design

8.2 Cost structure

8.2.1 Cost for New Meter Construction

SN	Items	Price (Indian market) INR	Price (Alibaba china) $
1.	LCD display(16x2)	140	2
2.	Current transformer	1,000	4
3.	Battery rechargeable	200	3
4.	Case	500	5
5.	Wires, resistors, transistors	200	1
6.	NodeMCU (ESP8266 module)	400	3
7.	Gsm sim900A mini module	1,200	8
	Total	3,640	$26 = 1,938 INR

Table 1.1- Cost for New Meter Construction

8.2.2 Cost for Redesigned Traditional Meter

SN	Items	Price (Indian market) INR	Price (Alibaba china) $
3.	Battery rechargeable	200	3
5.	Wires, resistors, transistors	200	1
6.	NodeMCU (ESP8266 module)	500	3
7.	Gsm sim900A mini module	1,100	8
	Total	2,000	$15 = 1,038 INR

Table 1.2- Cost for Redesigned Traditional Meter

8.2.3 One time development cost

SN	Task	Cost
1.	Dashboard Development	5 Lakh
2.	App Development	3 Lakh
3.	IoT Development	5 Lakh
4.	Cloud Setup	2 Lakh

5.	Penetration Testings	3 Lakh
6.	Q/A Testings	2 Lakh
	Total	20 Lakh

Table 1.3- One time development cost

8.2.4 Per Month Cloud Cost

SN	Service	Required for	Cost (per month)
1.	AWS IoT Core	IoT data pub/sub	$ 280
2.	AWS IoT Device Defender	IoT Security	$ 326
3.	AWS Lambda	Serveless coding (for less than 10000 requests per sec)	$ 387
4.	AWS Fargate	Serveless coding (for more than 10000 requests per sec)	$472
5.	AWS Step Function	Auto switching between AWS lambda or fargate as per need	$300
6.	Amazon S3	File storage	$250
7.	AWS API Gateway	API requests	$300

8.	AWS Kinesis Data Streams	Real time IoT data capture	$200
9.	AWS Kinesis Data Firehose	Real time IoT data filter	$200
10.	AWS Kinesis Data Analytics	Real time IoT data analysis	$800
11.	AWS Load Balancer	Traffic redirection to healthy lambda, serveless containers	$400
12.	AWS Cloudfront	Edge based content delivery	$470
13.	AWS Elasticache	Database memory cache	$300
14.	AWS Cloudwatch	Services monitoring	$500
15.	Amazon Redshift	Data warehousing tool	$1220
16.	Amazon Aurora Serverless	Enterprise level auto scaling database	$1000
17.	Amazon SNS	SMS and emails	$400

18.	Amazon Cognito	User authentication	$2000
19.	AWS KMS	Secret keys storage	$200
20.	AWS WAF	Web application firewall	$1000
21.	AWS Sagemaker	AI/ML algorithms	$800
22.	Monitoring and Security tools	Monitoring & Security	$5000
	Total		$16785 (20 lakh INR approx.)

Table 1.4- Per Month Cloud Cost

20 lakh monthly for 1 crore smart set (user and meter) i.e. 20 paisa per set. Also the GSM cost per month on data seems to be almost Rs. 2 maximum per month per device can be further reduced via partnership with network provides like Airtel, Vodafone, JIO etc.

CHAPTER-9

CONCLUSION

Hence, this paper includes the proposed model of a smart meter using AI and IoT to achieve the required goals of fleet management, real time data analysis and seamless visualization. Old meter is reused and redesigned such that re-modelling into the old module saves cost and new meter is designed for industrial application which is embedded with CT, VT, thermistor and other sensor for safe performance.

Normal meters are converted to digital smart meters in which data is send securely to reliable cloud platform and are visualized and processed for smart consumption in order to overcome lack of connectivity between consumers and producers, manual control and reading of electricity data, lack of result oriented energy data analysis and theft crisis.

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