Development and Control of an IOT-Based Smart Electricity Meter Using a Mobile Application

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Abstract

This is about the development of a prototype model of a smart electricity cadence that can be covered and controlled through a mobile operation. The proposed smart cadence is designed to give real-time monitoring of home appliance energy consumption and allow users to manage their energy consumption through a mobile operation. A smart cadence consists of a microcontroller, wireless communication modules, a mobile operation, and a power force. The microcontroller collects data from detectors that are connected to home appliances and sends the data to the mobile operation via wireless communication modules. The mobile operation displays the voltage, current, and power value of each appliance and allows druggies to turn off the appliances. The results show that the proposed smart cadence is effective in monitoring and controlling the energy consumption of home appliances. A wireless protocol and power cadence chip allow the SEM to measure the quantum of electricity used to communicate data.

Index Terms: Sensor, LCD Display, Wi-Fi Module, Energy, Microcontroller, Real-time Monitoring

I. INTRODUCTION

The growing demand for energy and the need to save energy have led us to develop intelligent energy systems that can provide real-time energy monitoring and operation [1]. Smart energy systems can help reduce energy consumption and improve energy effectiveness, which can lead to cost savings and environmental benefits. One of the pivotal factors in smart energy systems is the smart energy meter, which is designed to provide real-time energy monitoring and operation of home appliances [2].

In this paper, we present the design and development of a smart meter prototype that can be covered and controlled via mobile operation. One of the pivotal factors in the smart grid idea is power. These are instruments used to measure electricity and connect various biases to electrical networks. AMR (Automated Meter Reading) was the name of the idea that introduced the automation of electronic meter reading [3, 4].

Generality makes it possible to reach bias and collect the electronic data that measures consumer units. The data is also transmitted from the meter to the electric company using a radio [5, 6].

Frequency, telephone, and power lines, or satellite dispatches the added demand for energy consumption and the need for effective energy operation have led to the development of smart energy measures. Smart energy measures are biased, measure and cover the energy consumption of homes or businesses, and give real-time data to the user for better energy operation [7, 8]. IoT (Internet of Things) technology has enabled the development of smart energy measures that can be controlled and covered at any time [9]. With the help of a mobile operation, stoners can easily pierce and cover their energy consumption data, set energy operation pretensions, and admit caution when they exceed their pretensions [10, 11].

Developing an IOT-based smart energy meter prototype involves the integration of various factors such as sensors, microcontrollers, communication modules, and a mobile operation. The sensors are used to measure energy consumption and transmit the data to the microcontroller, which processes the data and sends it to the communication module. The communication module also sends the data to the mobile operator through the internet [12, 13].

A cutting-edge technology aims to provide an effective and convenient method for managing electricity consumption by developing and controlling a mobile application-based IoT-based smart electricity meter prototype [14]. Users will be able to control and monitor their electricity consumption remotely via a mobile application with the prototype [15].

The brilliant power meter utilizes IoT innovation to gather information on power utilization and communicate it remotely to a cloud-based server [16]. The server processes the information and makes it accessible to clients through a versatile application. The user-friendly interface of this application lets users remotely control their electricity use, set consumption limits, receive alerts, and track their usage [17, 18].

The advancement of the savvy power meter model includes a few phases, including planning the equipment, fostering the product, and coordinating the IoT innovation "[19, 20]. The equipment comprises the metering unit, which estimates the power utilization, and the correspondence module, which sends the information remotely to the server.

The cloud-based server processes the data and makes it available to the mobile application, which provides the user interface of the software [21, 22]. The Internet of Things (IoT) technology is incorporated into the system to facilitate seamless communication between the server, communication module, and metering unit [23, 24].

Overall, a promising technology that has the potential to revolutionize the way we manage our electricity consumption is the development and control of an IoT-based smart electricity meter prototype through the use of a mobile application. It makes it easy and effective to monitor and control electricity use, which helps cut down on energy use and encourages sustainability[25, 26].

The purpose of making this project is to provide users with effective way to monitor their electricity consumption. The controller will collect data form the sensors and transmit it to cloud server. The blynk IOT app will connect to microcontroller through internet and will show the output result on the LCD display.

II. METHODOLOGY

Controlling the prototype smart energy meter involves setting energy operation pretensions, entering cautions when the pretensions are exceeded, and ever-changing the energy consumption of the bias connected to the smart meter. This can be done through the mobile operation, which sends commands to the microcontroller to control the energy consumption. Overall, developing and controlling an IOT-based smart energy meter prototype using a mobile operation is a promising result for effective energy operation and reducing energy waste. Material and system paraphernalia and styles Smart meter attack installation the first step is to install the smart energy meter at the customer's demesne.

The installation process involves replacing the traditional energy meter with a smart meter that can cover energy consumption in real time. Mobile app development the next step is to develop a mobile app that can communicate with the smart meter and give real-time information about energy consumption to the stoners. Smart Meter: App Integration The smart meter and mobile app need to be integrated to ensure that they can communicate seamlessly. This involves configuring the smart meter to connect to the mobile app and setting up the necessary software protocols. Stoner registration and account

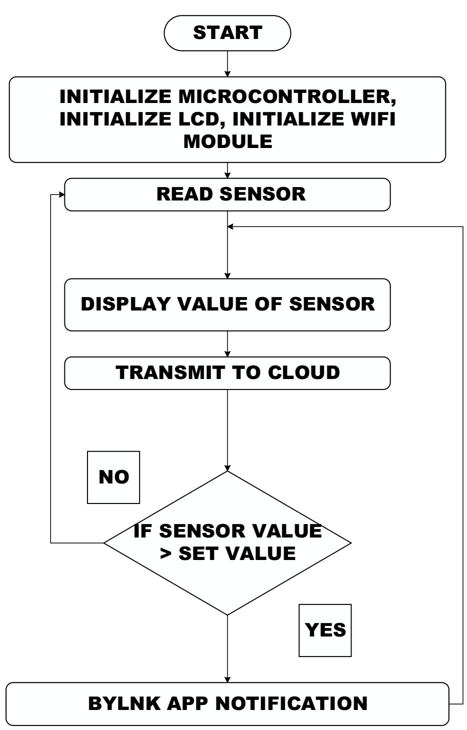

Fig. 1 Flow Chart of Methodology

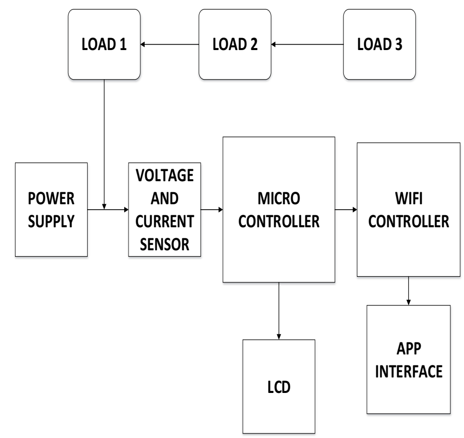

Fig. 2 Block Diagram of Smart meter Using Mobile App

creation. Once the smart meter and mobile app are integrated, the user needs to register and create an account on the mobile app. This allows them to capture real-time energy consumption data and cover their energy operations. Energy Consumption Monitoring and Operation The mobile app should give real-time energy consumption data, which allows stoners to cover their energy operations and take measures to reduce consumption. Billing and payment the mobile app can also provide billing and payment features, allowing stoners to view their energy bills

III. HARDWARE IMPLEMENTATION

Materials used:

- Microcontroller (ESP-8266 Development Board)
- Power supply
- Voltage and current sensor (ACL-712)
- Blynk IOT
- Bread Board
- 4-channel relay module
- 20x4 LCD Display

A. Microcontroller (ESP-8266 Development Board)

It is a self-contained SOC with an integrated TCP/IP protocol stack that can grant access to the WiFi network to any microcontroller. The ESP8266's input and output (I/O) operate at 3.3 V because it is a 3.3 V microcontroller. The chip will be destroyed if you apply more than 3.6 volts to any pin because they are not 5 volt tolerant. A single GPIO pin can only handle a maximum current of 12 mA. .It enables the microcontroller to connect to IEEE 802.11bgn-based 2.4 GHz WiFi. Through the use of an RTOS-based SDK, it can function as a self-sufficient MCU.

The ESP8266 has several GPIO (General Purpose Input/Output) legs that can be used for a variety of purposes. GPIO0 is used for flashing firmware and as a charge mode chooser. GPIO1 is used for UART communication and can be used as a general-purpose GPIO pin. GPIO2 is used for the I2C interface and can also be used as a general-purpose GPIO pin. GPIO3 is used for the SPI interface and can also be used as a general-purpose GPIO pin. GPIO4 is used for the SPI interface and can also be used as a general-purpose GPIO pin. Other legs include the ADC (Analogue to Digital Converter) leg, the reset pin, and the power legs. These legs can be configured and used for different purposes, depending on the operation.

B. Power supply

One of the most popular power supplies in use today is the power supply. A 5 volt output is produced at the end point from a 230 volt AC input using a combination as given below:

- Transformer
- Diodes
- Transistors
- Capacitors
- Regulators
- Resistors

The simple procedure to design a 5V power supply is:

Procedure:

- First of all, select all components as mentioned above.
- Place a transformer having a primary side of 1H and a secondary side of 5.4 mH.
- Connect a bridge of four rectifiers with it.
- Connect regulator 7086's first terminal with a rectifier bridge, the second terminal with a 330 ohm resistor, and ground the third terminal.
- Connect a capacitor of 2200 uF between the first and third terminals of the regulator.
- Connect a 230V and 50Hz frequency power supply with a rectifier bridge.
- Now at the end, place the voltmeter on the resistor and measure your output.

To design it, we will use the software Proteus. The schematic diagram of the 5V DC power supply is as below:

C. Voltage and current sensor (ACL-712)

DC is the ACS 712. According to the maximum current measurement range, there are three types of ACS 712. It can measure up to 5 A of AC or DC, 20 A, 30 A, or 40 A. The gain can be changed from 4.27 to 47, allowing us to measure a very small current. The ACS 712's no-load voltage is 2.5 volts, and the output voltage varies depending on the direction of the measured current.

The following formula may be used to get the ACS712's output voltage:

Utilizing the formula, the output voltage of the ACS712 may be determined:

Where;

- V_{out} is the sensor's output voltage.
- The supply voltage sent to the sensor is known as Vcc.
- The sensor's sensitivity is measured in millivolts per ampere (mV/A).
- I stand for the current in amperes (A) passing through the sensor.

A smart meter detects the voltage and current of the connected devices to calculate the amount of energy used. The intelligent electricity meter's operating theory is based on the following equation:

$$\text{Energy (kWh} = \text{power (kW)}^{x}\text{time (h)} \qquad (1)$$

$$\text{Power (KW)=Volt (V) x } \frac{\text{CURRENT(A)}}{1000} \qquad (2)$$

Using sensors, a smart electric meter calculates the voltage and current, then transmits the information to a microprocessor. Using the aforementioned calculation, the microcontroller determines how much power is used by the linked device. Following that, it computes the amount of energy used over time and communicates the information to the communication module.

The communication module uses the Internet to send data to the mobile application. The mobile application allows users to establish energy use goals and control how much energy is used by connected devices to the meter while displaying real-time energy consumption statistics.

The cost of the energy used may be calculated using the formula below:

Cost = Energy (kWh) x Price per unit (3)

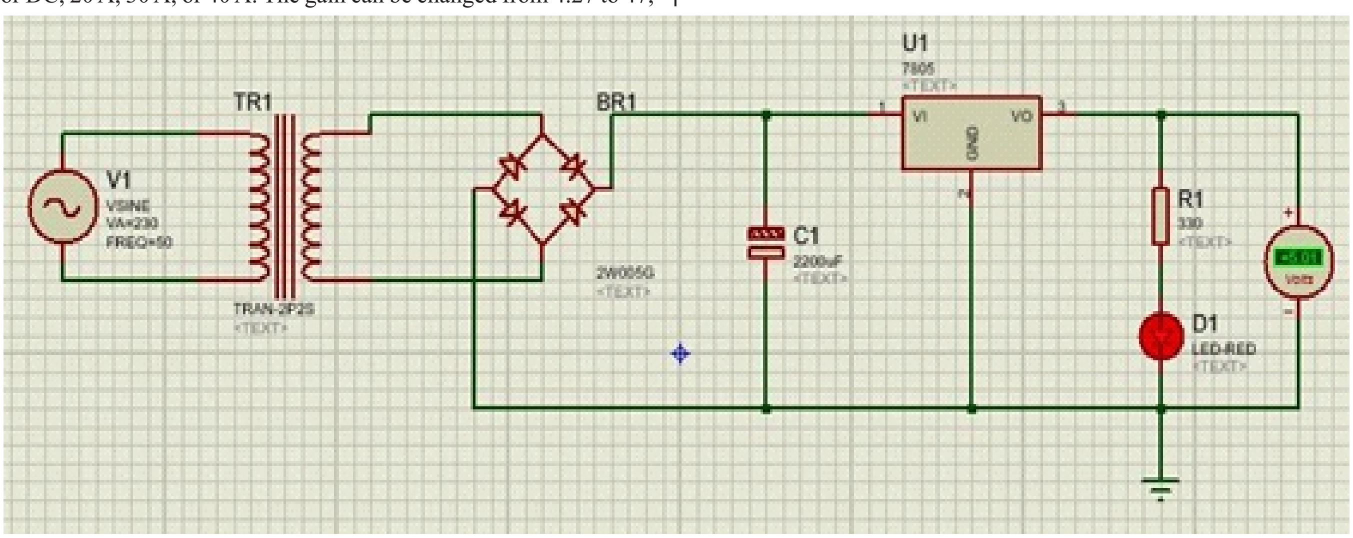

Fig. 3 Schematic Diagram of Power Supply

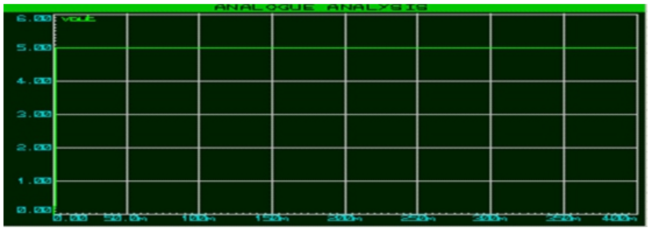

Fig. 4 Output Waveform of Power Supply

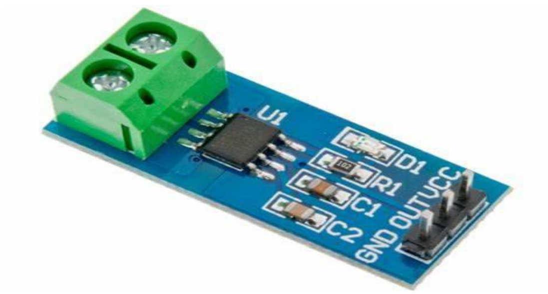

Fig. 5 Voltage and Current Sensor

Fig. 6 Mobile App Interface (Blynk IOT)

Where the price per KWh is the price of one unit of energy. This formula can be used to calculate the cost of energy consumed over time. It can be said that a smart electricity cadence works on the principle of measuring the voltage and current of the bias connected to it to calculate the consumed power and energy over time. Formulas used to calculate power and energy consumption allow the stoner to cover and manage energy consumption, leading to effective energy operations and reduced energy waste.

D. Blynk IOT

Drug users may now control bias like the Arduino, Raspberry Pi, and Node MCU thanks to the BLYNK IOT platform on IOS (iPhone Operating System) and Android phones. With the help of this operation, you may gather and provide the appropriate addresses on the devices that are accessible to create a graphical interface or human-machine interface (HMI). The open-source Java Garcon called Blynk Garcon connects the microcontroller and the Blynk app. The main benefit of using the Blynk app is that it's an assiduity- and hobby-horse-friendly tool that's dependable and scalable. By installing it on our mobile device, we can use it to track changes in energy consumption or voltage, the operation of current factors, etc. Blynk's abecedarian ackle consists of 32 virtual legs, pre

E. Breadboard

A block of plastic with several tiny holes in it is called a breadboard. You may quickly put together and test an early version of an electrical circuit using these holes, such as this one with a battery, switch, resistor, and LED (light-emitting diode).

F. 4-channel relay module

A useful piece of equipment, the 4-Channel Relay Module may be used to control high-voltage, high-current loads such as AC loads, motors, solenoid faucets, and lighting. The Arduino, PIC, and other micro-controllers may be connected to it. Using the four 5V relays and associated switching and segregating components from the four-channel relay module, together with the shortest feasible corridor and connections, a microcontroller or detector may be easily manipulated. The two terminal blocks, each with six outstations, each have two relays participating in them

Fig. 7. LCD Display

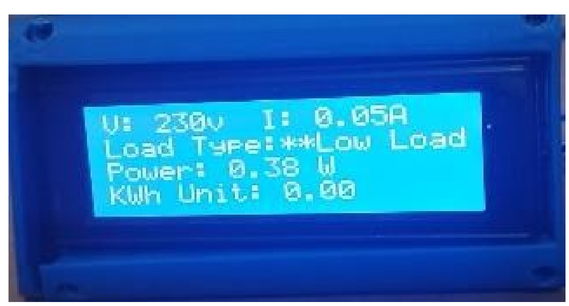

Fig. 8. Output Result when low load is on

Fig. 9 Output Result when Normal Load in on

G) 20x4 LCD Display

A 20x4 LCD module has four rows of display space; each row can hold 20 characters, and each display space can hold 80 characters. This liquid demitasse module makes use of an interface that resembles the regulator HDD44780, which is used to show snap textbook displays.

IV. RESULTS

The prototype of the smart electricity cadence was tested in a laboratory using colorful ménage appliances. The results show that the smart cadence is effective in monitoring and managing the energy consumption of home appliances. The mobile app displays the energy consumption of each appliance in real time and allows users to turn appliances off or on. The prototype is scalable and can be expanded with fresh detectors and wireless communication modules.

V. DISCUSSION

Prototyping a smart cadence using a mobile app can have significant benefits for both consumers and energy providers. Integrating a mobile operation into the electricity cadence enables remote monitoring and operation of energy consumption, leading to increased effectiveness and cost savings. In addition, druggies can fluently pierce real-time information about their energy consumption, allowing them to make informed opinions about energy consumption. One of the crucial challenges in designing a smart cadence with a mobile app is to make the app stoner-friendly and accessible to all consumers, regardless of their specialized moxie. The operation should be designed with a clean and simple interface and clear instructions on how to pierce and interpret the data.

In addition, the operation should be compatible with a wide range of mobile platforms, including Android and IOS platforms. Another

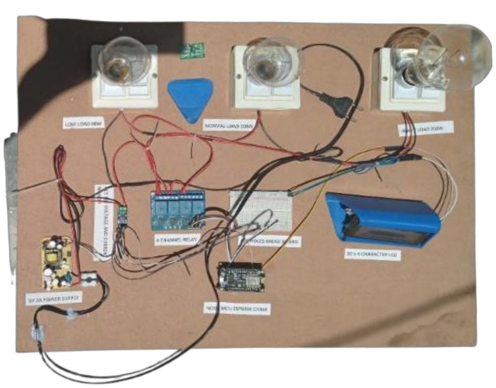

Fig. 10 Hardware Design

Fig. 11 Working of Hardware Design

important aspect when designing a smart electricity cadence is the security and sequestration of Stoner data. The operation should use encryption and other security measures to protect sensitive data and should comply with applicable sequestration laws and regulations. Overall, the design of a smart electricity cadence using a mobile app has the implicit ability to change the way we consume and manage energy, giving druggies more control over their energy consumption and contributing to a more sustainable future.

VI. CONCLUSION

The design of a prototype of a smart energy meter using a mobile app has the implicit intent to revise the way we cover and manage our energy operations. With the use of advanced technologies analogous to IOT, pall computing, and machine knowledge, the proposed smart energy meter can give real-time data on energy consumption, costs, and carbon footprint, empowering stoners to make informed opinions on energy operation and conservation. The mobile app interface offers a user-friendly and accessible way to pierce this data from anywhere, anytime, enabling stoners to cover their energy operation and adjust it accordingly. Also, the proposed smart energy meter can help utility companies optimize their energy distribution networks and reduce energy waste, leading to a more sustainable and effective energy.

REFERENCES

[1] A. Mohamed and O. J. E. P. S. R. Mohammed, "Real-time energy management scheme for hybrid renewable energy systems in smart grid applications," *Electric Power Systems Research Volume 96, March 2013, Pages 133-143* vol. 96, pp. 133-143, 2013.

[2] A. Razmjoo, S. Mirjalili, M. Aliehyaei, P. A. Østergaard, A. Ahmadi, and M. M. J. E. Nezhad, "Development of smart energy systems for communities: Technologies, policies and applications," *Energy Volume 248, 1 June 2022, 123540,* vol. 248, p. 123540, 2022.

[3] S. Ahmed, "Nature Inspired Optimization Techniques, A review for FANETs," *Sukkur IBA Journal of Emerging Technologies,* vol. 3, no. 2, pp. 40-58, 2020.

[4] D. S. A. Joshi, S. Kolvekar, Y. R. Raj, and S. J. B. I. J. o. R. i. C. E. Singh, "IoT based smart energy meter," *Bonfring International Journal of Research in Communication Engineering, Vol. 6, Special Issue, November 2016,* vol. 6, no. Special Issue, pp. 89-91, 2016.

[5] H. J. Muhammad Shahzad Pansota, HA Muqeet, Hamza Ali Khan, Naveed Ahmed, Muhammad Usama Nadeem, Syed Usman Faheem Ahmed, Ali Sarfraz, "An optimal scheduling and planning of campus microgrid based on demand response and battery lifetime," *Pakistan Journal of Engineering and Technology,* vol. 4, no. 3, pp. 8-17, 2021.

[6] V. Preethi and G. Harish, "Design and implementation of smart energy

meter," in *2016 International Conference on Inventive Computation Technologies (ICICT)*, 2016, vol. 1, pp. 1-5: IEEE.

[7] H. Durani, M. Sheth, M. Vaghasia, and S. Kotech, "Smart automated home application using IoT with Blynk app," in *2018 Second international conference on inventive communication and computational technologies (ICICCT)*, 2018, pp. 393-397: IEEE.

[8] M. Miškuf, E. Kajáti, I. J. I. J. o. I. o. T. Zolotová, and W. Services, "Smart metering IoT solution based on NodeMCU for more accurate energy consumption analysis," *International Journal of Internet of Things* vol. 2, 2017.

[9] S. Madakam, V. Lake, V. Lake, V. J. J. o. C. Lake, and Communications, "Internet of Things (IoT): A literature review," *Journal of Computer and Communications Vol.03 No.05(2015), Article ID:56616,10 pages 10.4236/jcc.2015.35021,* vol. 3, no. 05, p. 164, 2015.

[10] M. S. Liu Fei, Fazal Abbas, Hafiz Abdul Muqeet, Muhammad Majid Hussain, Li Bin, "Optimal Energy Management System of IoT-Enabled Large Building Considering Electric Vehicle Scheduling, Distributed Resources, and Demand Response Schemes," *Sensors,* vol. 22, no. 19, p. 7448, 2022.

[11] W. Hlaing, S. Thepphaeng, V. Nontaboot, N. Tangsunantham, T. Sangsuwan, and C. Pira, "Implementation of WiFi-based single phase smart meter for Internet of Things (IoT)," in *2017 International Electrical Engineering Congress (iEECON)*, 2017, pp. 1-4: IEEE.

[12] M. S. Junaid Masood, Zahoor Ali Khan, Vishesh Akre, Amala Rajan, Sheeraz Ahmed, Fawad Masood, "Effective classification algorithms and feature selection for bio-medical data using IoT," *IEEE 2020 Seventh International Conference on Information Technology Trends (ITT),* pp. 42-47, 2022.

[13] R. Mathur and K. Kalbande, "Internet of things (IoT) based energy tracking and bill estimation system," in *2020 fourth international conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud)(I-SMAC)*, 2020, pp. 80-85: IEEE.

[14] M. A. Khan *et al.*, "Prototype Model of an IoT-based Digital and Smart Door Locking System with Enhanced Security," in *2022 14th International Conference on Mathematics, Actuarial Science, Computer Science and Statistics (MACS)*, 2022, pp. 1-7: IEEE.

[15] D. Alulema, M. Zapata, and M. A. Zapata, "An IoT-based remote monitoring system for electrical power consumption via web-application," in *2018 International Conference on Information Systems and Computer Science (INCISCOS)*, 2018, pp. 193-197: IEEE.

[16] R. Govindarajan, S. Meikandasivam, D. J. I. J. o. S. Vijayakumar, and T. Research, "Cloud computing based smart energy monitoring system," *INTERNATIONAL JOURNAL OF SCIENTIFIC & TECHNOLOGY RESEARCH VOLUME 8, ISSUE 10, OCTOBER 2019,* vol. 8, no. 10, pp. 886-890, 2019.

[17] M. A. Omran, B. J. Hamza, and W. K. J. M. T. P. Saad, "The design and fulfillment of a Smart Home (SH) material powered by the IoT using the Blynk app," *Materials Today: Proceedings Volume 60, Part 3, 2022, Pages 1199-1212,* vol. 60, pp. 1199-1212, 2022.

[18] M. R. Asghar, G. Dán, D. Miorandi, I. J. I. C. S. Chlamtac, and Tutorials, "Smart meter data privacy: A survey," *IEEE Communications Surveys & Tutorials (Volume: 19, Issue: 4, Fourthquarter 2017),* vol. 19, no. 4, pp. 2820-2835, 2017.

[19] J. J. Lin, L. Mamykina, S. Lindtner, G. Delajoux, and H. B. Strub, "Fish'n'Steps: Encouraging physical activity with an interactive computer game," in *UbiComp 2006: Ubiquitous Computing: 8th International Conference, UbiComp 2006 Orange County, CA, USA, September 17-21, 2006 Proceedings 8*, 2006, pp. 261-278: Springer.

[20] M. Rupesh and N. A. Selvan, "Design of IoT based smart energy meter for home appliances," in *Journal of Physics: Conference Series*, 2021, vol. 1964, no. 5, p. 052001: IOP Publishing.

[21] K. Afsari, C. M. Eastman, and D. R. Shelden, "Cloud-based BIM data transmission: current status and challenges," in *ISARC. Proceedings of the International Symposium on Automation and Robotics in Construction*, 2016, vol. 33, p. 1: IAARC Publications.

[22] A. Kumar, S. A. Alghamdi, A. Mehbodniya, J. L. Webber, S. N. J. S. E. T. Shavkatovich, and Assessments, "Smart power consumption management and alert system using IoT on big data," *Sustainable Energy Technologies and Assessments Volume 53, Part C, October 2022, 102555,* vol. 53, p. 102555, 2022.

[23] Y. J. R. Kabalci and S. E. Reviews, "A survey on smart metering and smart grid communication," *2015 IEEE Electrical Power and Energy Conference (EPEC),* vol. 57, pp. 302-318, 2016.

[24] M. H. Yaghmaee and H. Hejazi, "Design and implementation of an internet of things based smart energy metering," in *2018 IEEE International Conference on Smart Energy Grid Engineering (SEGE)*, 2018, pp. 191-194: IEEE.

[25] A. Al-Ali, T. Landolsi, M. Hassan, M. Ezzeddine, M. Abdelsalam, and M. Baseet, "An IoT-based smart utility meter," in *2018 2nd International Conference on Smart Grid and Smart Cities (ICSGSC)*, 2018, pp. 80-83: IEEE.

[26] M. Prathik, K. Anitha, and V. Anitha, "Smart energy meter surveillance using IoT," in *2018 International conference on power, energy, control and transmission systems (ICPECTS)*, 2018, pp. 186-189: IEEE