MONITORING OF ELECTRICITY CONSUMPTION THROUGH INTERNET OF THINGS (IOT) TECHNOLOGY: A CASE OF TANZANIA

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Abstract— With the introduction of Internet of Things (IoT) technology, where many appliances are installed and used in every home, there is an increase in electricity consumption and electricity cost. As electricity costs increase, users are becoming actively interested in reducing their electricity consumption. The interest is due to the awareness regarding reducing the consumption. This paper presents the initial stage of research that focuses on integrating smart meters, sensor nodes, a gateway with a well-known cloud platform, and mobile network devices. The proposed methodology uses smart home appliances to communicate through sensor nodes. The data collected is uploaded to the cloud that the electricity consumers access through mobile in a text or voice messages format.

The proposed solution is expected to support users to control their electricity usage. This will also reduce their billing, conserve electricity, and enable the user to keep track of the real-time electricity consumption. Moreover, monitoring electricity consumption and usage is intended to bring benefits to electricity consumers and utility providers.

Keywords: — Sensor nodes, smart meter, cloud platform, electricity consumption monitoring.

I. INTRODUCTION

Electricity monitoring is one of the important applications arising from research on the Internet of Things (IoT). There should be an understanding of the demand, production, and optimization of energy for users. This will be significant to end-users to monitor as well as control their electricity consumption. This research intends to solve the background of the problem in the field of IoT of electricity as it may grow rapidly and Co2 emission by electricity production side will increase. There is a need for a way to solve those issues by predicting the exact production of electricity for electricity consumers. This will resolve global climate as well as sustainability matters in our everyday life. The background of the problem demanding, Supplying and consuming electricity is a challenge as utility companies cannot produce and supply enough electricity. Normally, there is no proper way of electricity consumption monitoring and identification of electricity leaks in the customers' households. The Internet of things technology has brought the use of many appliances, devices at home for many people. Electricity consumers are much concerned about the high cost of their electricity consumption. The high-level IT infrastructure that will be used to put together different technologies to produce an optimum framework for monitoring as well as evaluating utility usage in household settings. In this this paper, the parameters like Kilowatt per hour (Kwh) and time are monitored and controlled using a microcontroller. This is a device that integrates different IoT modules and then transmitted to the ESP 8866 module through a microcontroller should receive the transmitted data. Data is saved on a cloud platform for storing, processing, and better analysis. In that case, the technology used to improve electricity consumption by implementing an easy-to-use, advanced monitoring infrastructure. Such infrastructure will monitor utility usage, provide conservation advice to users and prevent waste of utilities [1]. The result in this literature revealed that device infrastructure to be researched as well as implemented focuses on reducing the service leakage that happens in different households. It is important to monitor and control the operation of user's loads depending on the collective electricity consumption over the desired period and the peak electricity consumption. This research focuses on the use of modern technologies for electricity consumption monitoring.

Related works

This section reviews other works that are closely related to this research. Weaknesses, as well as strengths of the reviewed works, are pointed out. The idea of this research arised from the fact that there is no reliable Internet of Things (IoT) architecture for better consumption of electricity in households. Moreover, people are unaware about the proper use of household appliances, as well as by what means utility provider's production satisfies demand from end-users. In that situation, there is a need for a hardware device connected to a smart meter to sense the usage of electricity by different appliances when they are switched on. This requires using the Internet of Things (IoT), as proposed in this work.

In the following section, we will review some important articles

that are closely related to this research to get a clear insight into the current practice and the gaps that need further investigation. Several works have studied IoT architecture. Terroso-Saenz et al. [2] described the centralized architecture to monitor energy consumption in houses. They pointed out that IoT energy platforms should include other functions for better data analysis. Moreover, they highlighted the implementation and energy management issues of IoT platforms. In this work, the IoT based architecture proposed the use of a smart home controlling system using Web, smart home interface, and Global System for Mobile Communications (GSM) based design [3]. The focus is to extend implementation with video streaming of electrical household appliances using GSM-MMS. The authors proposed the prototype that operates for data gathering and transmission using GSM-SMS preceding test. Last, this research [4] should consider data transmission as well as security of the authentication.

Figure 1: shows other existing general IoT system architectures for electricity monitoring. This system has been introduced into a house to realize further extra energy saving.

The appliances are connected to a network, to make it possible to work on different household appliances, The improved interlocking controls and power even out controls are realized using information from Internet, such as temperature and weather information. Analysis systems that preserve appliances at the maximum state, as long as to connect appliances to maintenance service.

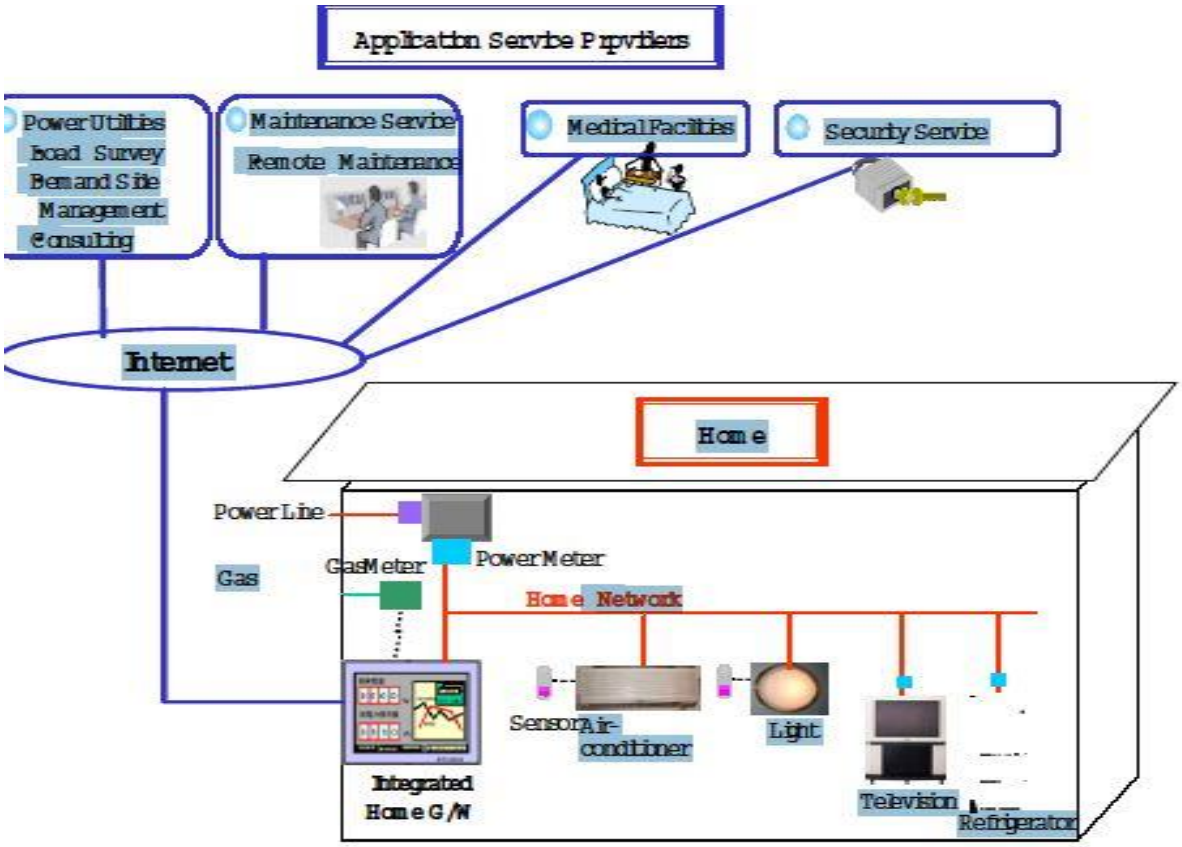


Fig 1: The Existing General IoT System architecture for electricity monitoring

Therefore, advanced IoT architecture is needed to improve any of these two IoT architectures for electricity monitoring. The smart meter is mainly able to communicate through all-electric utilities. Also, all data are read from the meter to the analyzer's server, besides data receive a secure and reliable operational response.

The research review indicates various Internet of Things (IoT) Energy platforms. However, in [7], the authors show that there is still a lack of platforms that focus on household energy. Thus, there is a need to provide more support for data analysis. However, the study only focuses on Smart meters for doing remote monitoring of the consumption of electricity. The

contribution of this research is mainly based platform that focuses on smart meters that remotely monitor the consumption of electricity and reduces energy usage. In the research, however, the researchers did not show any method.

Additionally, there is a scalable platform that is used for mining and processing a large number of datasets, as well as a web portal for visualizing analytics results [8][9][14]. Likewise, in this work, there is a platform designed for searching and integrating different data processing units as well as different algorithms, However, despite of the existance of an analytic algorithm, the efficiency of that algorithm to other algorithms has not been considered. Contrarily, they compared them using the same platforms. This research was supposed to show the efficiency of analytical algorithms with others algorithms in different platforms.

Arshad, R et al. [9] focus on an efficient implementation of Internet of Things (IoT) in controlling and monitoring home electrical appliances through the World Wide Web. Also it both control and continuously monitor systems that control various home electrical appliances with an Android smartphone. Additionally, the contribution includes the communication with the smart meter to get the details of usage of home electrical appliances that finally communicate with the application layer.

A local system between the smart meter and the electrical household appliance is also a design of the network architectures proposed in [10, 11, 15]. It establishes two-way communication between the house users to secure electricity supply. Bin, X [10] suggested that the meter should provide greater independence from the concentrator and interact more efficiently using the electrical household appliance, making enough information available. Meanwhile, the users will get back their energy usage after utility providers get detailed information about energy usage [12]. There is a need of reducing the scale of smart meter deployment. Consequently, there is an algorithm [13] that they implement that shows that the number of smart meters in many power loads networks significantly be reduced, Finally, one of the objectives of this research is to propose advanced IoT architecture for better consumption of electricity as well as an efficient balance between consumption and demand where the smart meters are “things” on the Internet. This research [16] presented a mobile application that is potential to the users based on their feedback. The contribution of this research includes smart meters for fetching the electricity reading IoT board. Different energy-efficient researches have been done. Some of them are reviewed here below.

One of the researches integrate multiple aspects of human beings needs.To satisfy such needs, the analytical requirements were discussed, for example, big data, real-time, and stream analytics. Also, in [18] they described smart meter data as big data also presented the smart metering landscape that is used to position diverse meter data analytics applications. The proposed solution is that the analytic techniques used are not novel. Therefore, there is a need to propose novel analytics for consumption data.

II. METHODOLOGY

THE PROPOSED SOLUTION

Fig. 2 shows the system model that comprises an internet-based system that includes the integration of smart meter, sensor nodes, a gateway with a well-known cloud platform, and mobile network devices. Likewise, the user controls have the mechanism of the system like switch on/off the smart appliances used to adjust the consumption of electricity. All smart home appliances communicate via sensor nodes, while all data go to the cloud. The data in the cloud be accessed by the user through mobile, either through an internet connection; otherwise, the summary of the information is sent to the user through a text message and voice messages.

Within this solution, the parameters like Kwh and time are monitored and controlled using a microcontroller. A device that integrates different IoT modules and then transmitted to the ESP 8866 module through a microcontroller should receive the transmitted data. Data is saved on the cloud platform for storing, processing, and better analysis.

ESP 8866 board is also used to add WIFI local networks so that all measured data is sent to the cloud to help users control or monitor their households' electricity through any mobile devices. Data gathered play a big role in the community side as well as utility companies for advising users on electricity consumption and knowing the exact demand of electricity for their users. The electricity utility companies can balance demand and production and produce optimal offers for their users. The system can generate real-time-based data to the cloud.

Expected users of this proposed model are:

Scientists (Researchers): Team members will sharpen their skills during the implementation of the project and follow-up research questions will be identified. Other researchers will benefit from the results of the project. Policymakers will have accurate and reliable data for policy formulation and evaluation. Energy utilities will also benefit from the results of the proposed model. The regulator is also a potential beneficiary of the outputs of the model. Consumer protection associations will also have accurate data for their advocacy programs. Investors also will use the outputs of the model. End-user like electricity clients will be able to control their electricity usage. Government policy will upgrade their electricity policy, guidance, and regulations. Industries will efficiently use electricity for the stability of production.

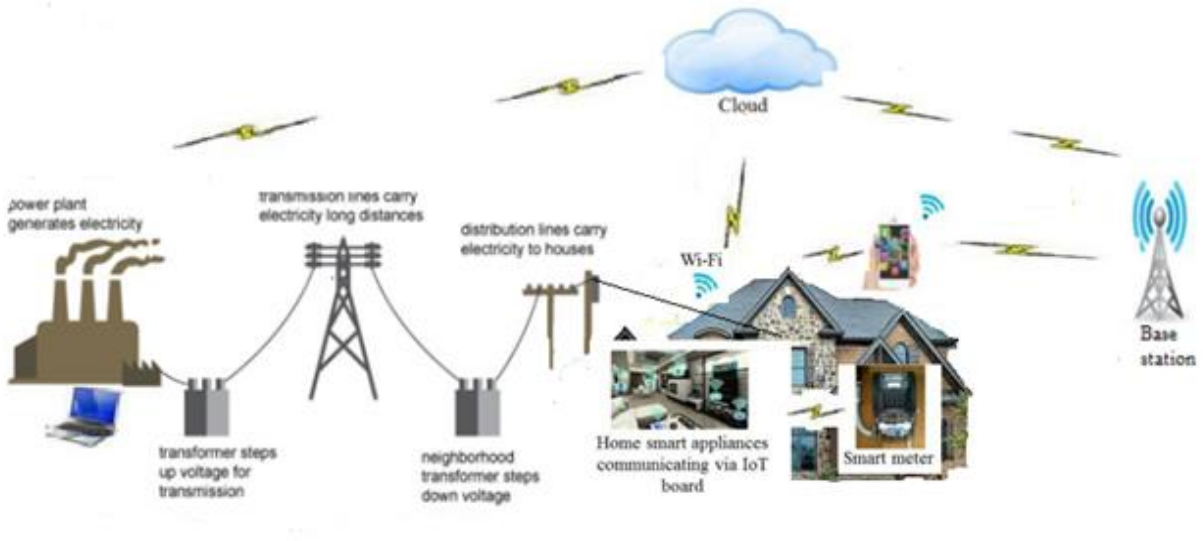


Fig. 2: *Shows the proposed advanced IoT architecture for electricity monitoring*

Based on the diagram above, all sensed data is sent to the cloud, and users can get real-time electricity usage information.

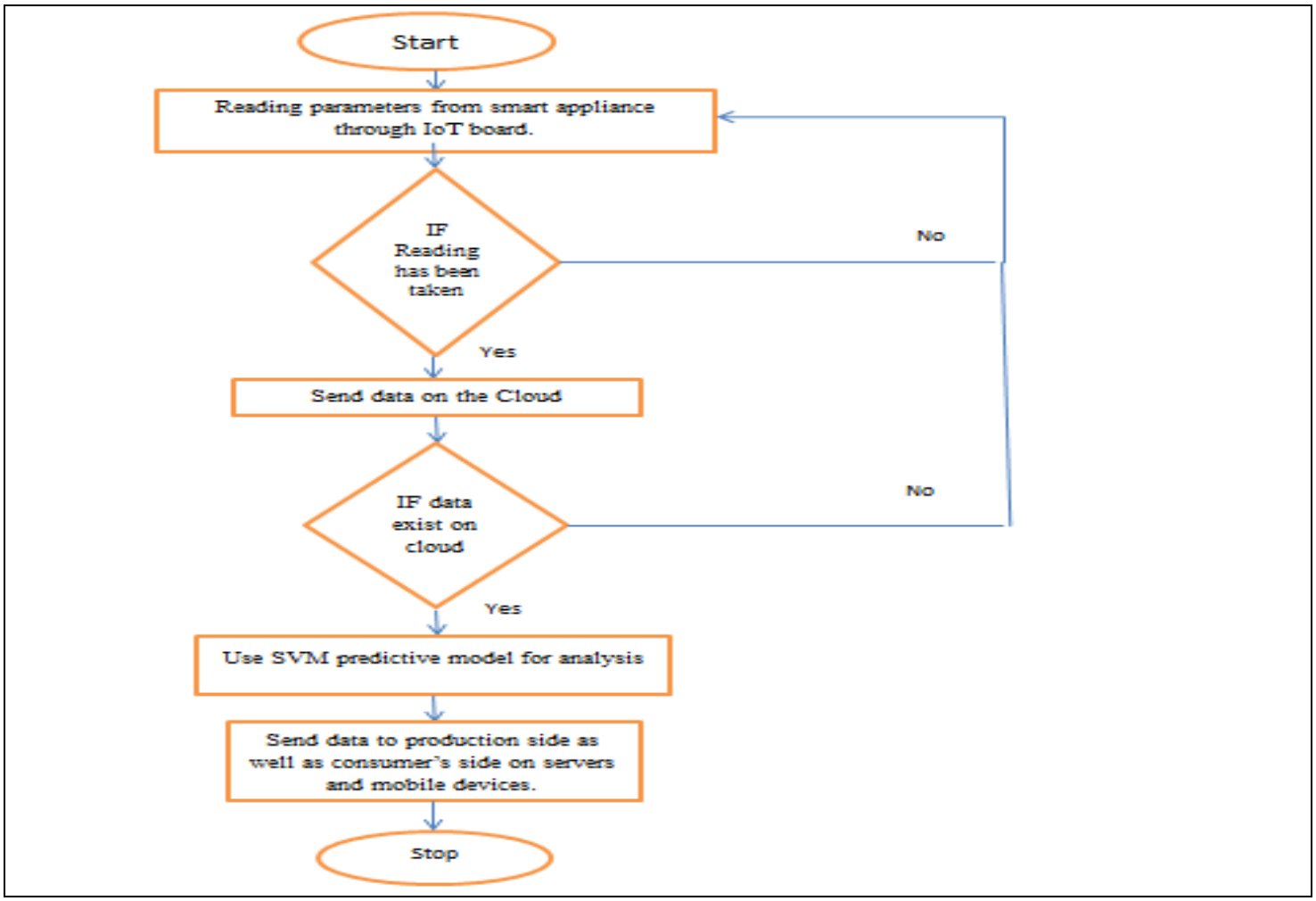
This research's main objective is to monitor electricity consumption through IoT technology based on measured data in regular running conditions. To achieve this objective, we propose to use of a predictive model established on support vector machines. We want to demonstrate the relationship between the predictability of different input parameters as well as the output of the model.
In this research, we will evaluate the predictive electricity of the support vector machines (SVM) and compare its results with dignified data.

This algorithm of the support vector machine (SVM) will utilize these variables: the total number of home smart appliances, electricity production (Kwh), and the units per time (Kwh). The SVM will be trained with different data from different ranges of months. For our proposed model to measure the performance then normalized root mean the square error will be used.LIBSVM [19] is a software tool that contains support vector machines that solve several kinds of problems; among them is regression estimation. Several decades ago, support vector machines are constructed on the statistical learning theory developed by Vapnik and Chervonenkis [20].
Training data {(x1, y1),…,(xn,yn)}, the SVR will use the input vector x as well as calculates the function that greatest describes the actual output data y through an error tolerance ε.
[21].
The root means square error will determine an average of all the deviations from the measured data and predicted data values.

The following steps will be performed:
1) Determination of the independent variables as well as dependent variables.
2) Splitting the different data from different months ranges to measure them, testing and validating them.
3) The root mean square error will determine less error among the ranges of data set among the validation set
4) The results will be given and plotted.
5) The results will be compared with another IoT model.

Hence, the SVM algorithm will be repeated for different mixtures of both parameters inside a range, so only the qualified support vector regression(SVR) that optimize the error will be considered for electricity consumption prediction.

The block diagram below explains the functionality of the proposed architecture and SVM predictive model for data analysis on it.



III. CONCLUSION

This research presents the literature of ongoing research on the IoT technology in electricity consumption helps the user monitor the internal electricity consumption and get all details about their usage from anywhere and anytime.

Usage of mobile devices, especially smartphones, can help the user monitor their consumption and control their smart appliances by a switch on/off. In addition, weather parameters such as humidity and temperature will be considered. This research is expected to continue to the next phase of its implementation.

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