A short overview of IoT based energy metering system

Part III IoT based electricity theft detection and bill generating system

O scurtă trecere în revistă a sistemului de contorizare a energiei electrice dotat cu internet

Partea III Sistem de detectare a furtului de energie electrică și generare a facturilor

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Abstract
In this connected world, the development and widespread use of smart devices has led to a new beginning for machine-to-machine communication anytime and anywhere. As artificial intelligence spreads, this connectivity has created a completely different vision of the Internet of Things (IoT). The IoT has led to the emergence of a virtual network between man and the physical world of various things, thus drastically changing the way various businesses operate. In this context, the paper below describes a system of reading electricity meters based on the IoT and integrated circuits containing microcontrollers known commercially as Arduino. In this paper we also present a remote electricity billing system. This billing process is faster and more efficient, enabling customers to pay their bills earlier.

Key words: *electricity theft, Internet of Things (IoT)***,** *billing system*

Rezumat.
În această lume conectată, dezvoltarea şi utilizarea pe scară tot mai largă a dispozitivelor inteligente a condus la un nou început pentru comunicarea de tip maşină - maşină în orice moment şi în orice loc. Pe măsură ce inteligența artificială se răspândește tot mai mult, această conectivitate a creat o viziune cu totul aparte cu privire la internetului obiectelor (sau lucrurilor). Internetul lucrurilor a condus la apariţia unei reţele virtuale între om și lumea fizică formată din diverse lucruri, schimbând astfel drastic modul în care funcționează diverse afaceri. În acest context în lucrarea de mai jos se descrie un sistem de citire a contoarelor de energie electrică bazat pe internetul obiectelor şi circuite integrate care conţin microcontrolere cunoscute comercial sub numele de Arduino. În cadrul acestei lucrări prezentăm de asemenea şi un sistem de facturare a consumului de energie electrică la distanţă. Acest proces de facturare este mai rapid şi eficient dând astfel posibilitatea clienţilor, să poată plăti facturile mai devreme.

Cuvinte cheie:*, furtul de energie electrică, internetul obiectelor (IoT), sistem de facturare*

1 Introduction

Energy emergency is one of major problems that the world faces today. The best remedy for this is not the increases in energy production, but the effective use of available energy. By properly monitoring energy consumption and avoiding energy wastage, energy emergency can be reduced to a certain extent. But energy monitoring cannot be done efficient mainly because consumers are not aware of their energy consumption.

They will get an idea about their consumption only when the electricity bills are issued. Usually bill is issued only once in a month or two months. So the consumers will be in dark during this period of time about their energy usage. In this era of complete digitalization, no one will take the pain to go and check their electricity meter reading and compare it with the previous reading so as to get an idea about their consumption. This whole procedure has to be repeated several times in a month to efficiently control the energy usage. If consumers can check their energy consumption using their mobile phone or laptop instead of checking energy meter, it will be a great leap in the area of energy management. Since most of the people are today 24*7 online, it will be really a boon if they can monitor their energy consumption online from anywhere on the globe. In this paper, we are describing a method of electricity energy meter reading using IoT concept [1].

To check electricity consumption by using mobile phone or laptop instead of checking energy meter, can be used an energy meter that involve the IoT concept, (see Part II of this paper). So, there is a way for a consumer to track their electricity consumption from time to time so that they can better control their consumption and manage their budget. This system is useful for both consumers and supply.

This method makes it impossible for a certain consumer of electricity to intervene if he is disconnected from the power supply system as a result of non-payment of electricity bills or theft. In other words a system for measuring electricity consumption based on the Internet of Things (IoT) plays a vital role to inform supplier about any theft that is happing in the network [1].

2 The system for detecting electricity theft

Electricity power theft which is a non-technical electricity power loss is one of the major issues of each developing country. These non-technical losses of electricity are difficult to estimate. In the current electricity metering system, manipulation for the purpose of stealing electricity can be easily done.

Detection of electricity theft has traditionally been approached through physical checks of obvious handling seals by field staff and the use of meters. Although these techniques reduce unmeasured and unbilled electricity consumption, they are insufficient. Indeed, tamper-proof seals can be easily broken, and while meters can detect that some customers are fraudulent, they cannot accurately identify culprits.

There are many methods which have been proposed for theft detection. Many of these methods include load profile analysis of customers to detect abnormal energy consumption patterns. But these methods cannot be used to detect energy thefts when there is a complete bypass of electricity meters. In such cases, electricity losses are

calculated by using energy balance between the energy supplied from the distribution transformer and the energy consumed at the consumer's end. An effective way for estimating non-technical losses in the electricity distribution network is correctly estimating the technical losses in the network and then subtracting it from the total loss in the network [2-3].

One of the newest and most modern methods of detecting non-technical losses in the transport of electricity is a method that works on the basis of the Internet of Things [3], [4-8].

A general system architecture for energy monitoring using IoT (see fig 1) can be made up of:

a) bottom layer which contains smart meters and sensors, which may be connected through wired or wireless networks. Smart energy meters available on the market can attain several parameters (e.g. power consumption, max/min of peak voltage and power factor), hence they provide a high level of flexibility in monitoring and analyzing energy consumption.

b) an intermediate level, from where the collected data is sent to a gateway and then transferred to a local computer or the Internet via standard communication protocols such ZigBee.

Eventually, data are fed into Enterprise Energy Management (EEM) software for analysis, into other enterprise systems such as: Building Management Systems (BMS), Advanced Production and Scheduling systems (APS), Manufacturing Execution Systems (MES), Manufacturing Resource Planning (MRPII), or simply into the Enterprise Resource Planning (ERP). The data from smart metering systems can also be integrated with a supervisory control and data acquisition system (SCADA)

In the design of smart energy meter, (see part II of this paper) the microcontroller is interfaced with AMR module, theft detection module and Wi-Fi module. The microcontroller is a core component of the smart energy meter system which is placed at the consumer end for the purpose of measuring the meter reading, theft detection and storing the data. This data is transferred between consumer end and energy supplier end using IoT module (ESP3866 Wi-Fi). The AMR module continuously monitors the meter and collects the reading and sends to the microcontroller. In the current scenario, there is a need to uniquely identify the smart meter device remotely in a reliable manner. To achieve the characteristic of device remotely we have provided IP address for each connection. In this paper we have concentrated on the theft detection, optimum utilization of power and convey the energy consumption information to the user end.

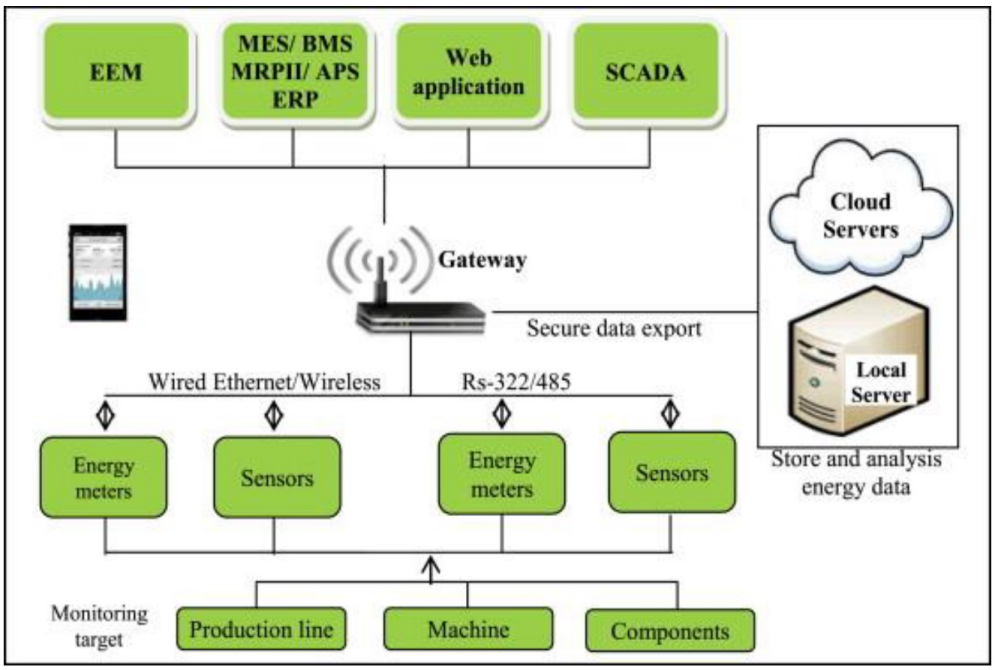

Fig 1. General System Architecture for Energy Monitoring Using IoT [9]

At the consumer end, the power supply module provides the entire power needed by the system to function. Also this power supply charges the Backup Domain Controller[1] (DC Backup) so that when there is no power from the utility company, the DC Backup can energize the system. Microcontroller is used to collect and store the meter reading information from the electricity meter and also performs the control process and sends the required information to energy provider such as number of units consumed using Wi-Fi module. The purpose of LCD module is to get visual information about the number of units consumed, alert messages and connection status. This is a backup power supply unit (DC backup) for the system. The purpose of the DC backup is to makes the system active even there is no energy supply from the utility company. A small 8.4V, 5600mAh rechargeable battery is used here

3 Bill generating system

As time goes on, technology is becoming more and more a part of our daily lives. Although there is unprecedented progress in science and technology today, this progress is not always fully utilized. One such area where improvements can still be made is the area of electricity billing and payment.

Since for electricity board (EB) an automated billing system [10]

1. the need to pay the bills at the EB office

2. allows the user to: **a)** get updated details of the power used in his house, **b)** check if the invoice received is correct or not

[1] A backup domain controller (BDC) is a role a Windows NT computer takes on to help manage access to network resources

3. the wireless method sending data is feasible even when more buildings are being built into the network,
in this part of the paper we will present a system for billing electricity consumption based on the Internet of Things (IoT) [11-16].

An invoice generation system based on the Internet of Things consists in the continuous monitoring of an intelligent electricity meter, i.e, in collecting the consumed units, generating the invoice and sending it automatically to the user. Therefore in the automated EB billing system there are two modules namely EB office module and customer home unit (see fig. 2)

The EB office module consists of a database at the back end for storing values which are got from the home module. After the values are got from the home units the cost is calculated and the values are sent back to the home unit and they are displayed in the LCD display for the user to make note of it.

Customer home unit includes a energy meter that informs the consumer the exact consumption and billing that the load consumes through IoT, ATmega328 microcontroller, which is used in Arduino-Uno platform applied in case of communication through IoT, ESP8266 Wi-Fi module which allows the circuits to be connected to the internet, a liquid-crystal display (LCD), 12V relay, server (web page) and load

An intermittent LED, mounted in the meter, emits pulses that are directly proportional to the electricity consumed. power consumed. The higher the electricity consumed, the faster the intermittent pulses of the LED. To obtain the value of energy consumed in real time above the flashing LED, a sensor is mounted, the output of which is connected to an ATmega328 microcontroller

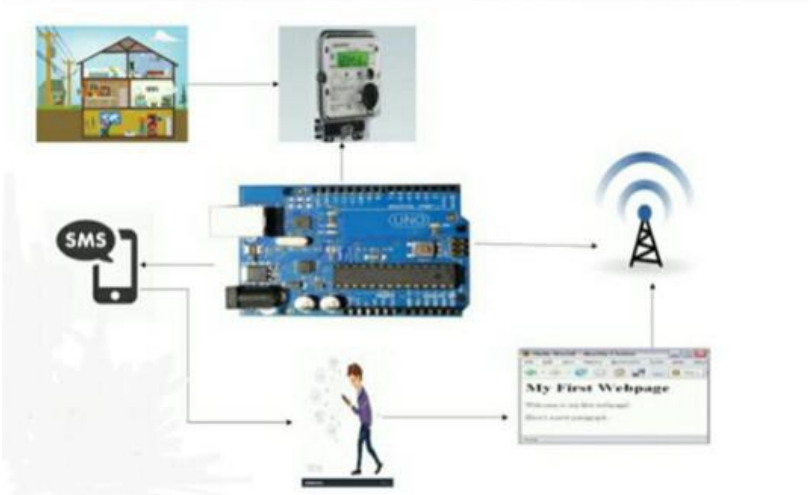

Fig.2: Block diagram of bill generating system [15], [17]

Whenever the LED blinks, it then gives an interrupt signal to the microcontroller of the ATmega328 family and thus the program of the microcontroller counts the pulses and displays the reading on the LCD duly interfaced to the

microcontroller for every minute / daily / weekly or monthly as programmed which is sent to the screen of server. For every 30 seconds, the PIC controller tries to send the value received to the central public server through IoT. We are using Wi-Fi which acts as a heart for IoT. Through Wi-Fi the consumer can set changes in threshold value, it can ON and OFF the energy meter. When the load connected to the meter is ON then the meter will start counting the watt hour cycles being used, interface is provided between energy meter and microcontroller by means of a step down transformer and C program is embedded into the microcontroller which helps it to calculate the number of units used by the consumer by means of input KWH cycles taken by energy meter and the relay will operate for disconnecting the load. The calculated units are displayed on an LCD which is connected to microcontroller. By this user can manage his usage of power and save the electricity and plan his budget.

Daily energy consumption can be monitored and viewed through a graphical representation using a web portal or web page. The daily limit of energy usage can be set. The server collects all information received from the energy meter units installed in every home and stores it in a central database. It is accessible to end-users through web portal/mobile app. End-users can monitor their energy consumption and view their bills. Monitoring server actively monitors for the data from the energy meter and records the information received in the database. The switching of any load can be done. The web page will have a admin login option so that we can keep our system secure. This page can be access by both server and consumer. Bill generation is done automatically by this server at the end of every month without any manual work involved.

4 Conclusions

In the most of the developing countries, the effort of collecting electricity utility meter reading and detecting illegal usage of electricity is a very difficult and time consuming task which requires a lot of human resources. Energy meter reading and monitoring system using Internet of Things (IoT) present an efficient and cost-effective way to transfer the information of energy consumed by the consumer wirelessly as well as it provides facilities to detect the illegal usage of the electricity. Such a system also allows the automatic generation of the bill necessary to pay for electricity consumption. This system which helps in controlling energy consumption and avoiding energy wastage is very important. The system is based on an Arduino and implementation of energy meter using IoT concept.

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