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Theft Detection and Disconnection in Automated Electricity Energy Meter: A Survey

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Abstract: ***In this paper, we study and discuss various automated systems for electricity energy meter. These systems provide automation and eliminate human involvement for meter reading process, theft detection and disconnection of electricity transmission. These automated systems provide accuracy in billing and also enables the consumers to do power optimization by providing electricity consumption information on frequent basis. This consumption information can be provided to the user either through Webpage, Android application or through SMS. This paper focuses on various techniques that can be used for providing security to electricity meter from electricity theft attempts. Theses automated systems also introduce automatic disconnection of the electricity in the case of any tampering happens or in case where consumer fail to pay the electricity bill on time. This paper also discusses various challenges of existing system and how the automated systems can overcome from them.***
Keywords*: *Internet of Things (IoT), Electricity Board (EB), Global System for Mobile communications (GSM), General Packet Radio Services (GPRS), Radio Frequency (RF).

I. INTRODUCTION

Electricity is the major invention that plays a vital role in the development of any country. The increase in the consumers of electricity causes companies to have some techniques for precisely measuring electricity energy consumption so that accurate bills can be generated.

The data collection of energy consumption and distribution for billing and monitoring plays very vital role in energy Analysis. Currently in India , an authorized person of EB (Electricity Board) visits each consumer's place and note down consumed energy units and according to that charges are calculated for consumed units of electricity. It is a time consuming process in which problems may arise due to error caused by authorized person.

The automated system design will eliminate human intervention in electricity meter reading by incorporating various technologies with electricity energy meter. With this system consumer can check his electricity usage periodically either through android app or webpage. This can help the consumer for power optimization which is very important for development of country.

In existing system, meter tampering can be done easily for the purpose of electricity theft. It is one of the major problems of electricity grid. There are many systems designed for detecting electricity theft attempts.

Each consumer needs to pay an amount per unit usage of electricity on schedule. In automated system, if the consumer fails to pay the electricity bill in given period of time then electricity transmission can be turned off.

II. AUTOMATEDMETERREADING

To automate this metre reading process many system designs have been proposed based on different technologies like GSM (Global System for Mobile Communication), GPRS (General Packet Radio Service), ZigBee technology, RF Communication methods.

A. ZIGBEE Technology

1) To overcome the limitations of the traditional manual meter reading system, a wireless technology called as “ZIGBEE” is used to provide the automation in meter reading system.

ZigBee is an IEEE 802.15.4 standard basically used for communication among different consumer devices in a frequency band of 2.4 GHz. ZigBee has an operating range of about 10m- 2km. ZigBee is a low cost, low powered wireless networking mechanism based on mesh topology. A processor which is directly interfaced with ZigBee module continuously monitors the consumed units of electricity from the electricity energy meter. The LCD display indicates the energy consumption in terms of unit consumed, monthly bill in INR.

2) Microcontroller collects the consumed electricity units from the electricity energy meter through interface circuit and process them. After that ZigBee device transmits this low rate digital data into the network of ZigBee concentrator. The electricity energy

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meter and EB server station may have long distance between them; hence it sends data from electricity energy meter to that server stations through various types of communication network such as mesh, star, cluster, etc. ZigBee Router allows routing of the data from one device to other. ZigBee plays an important role in monitoring power utilization and efficient power optimization. It works on low data rate of 20Kbps to 250Kbps with a very less power consumption. Range Extender is used to cover long distance in a network. But ZigBee network is less secure, involves high cost replacement, not efficient for long distance communication.

B. Rfid Technology

[3]Radio-Frequency Identification (RFID) is one of the wireless automatic identification methods. It is mainly based on the strategy of storing and remotely retrieving data using devices called RFID tags or some time referred as transponders. An RFID tag is an object that can be easily incorporated into any product, animal, or person for the purpose of identification and tracking using radio waves. Some of the RFID tags can be read from several meters away and beyond the line of sight of the RFID reader. The RFID technology requires a cooperation of an RFID reader and an RFID tag up to some extent for successful communication. The RFID technology can be used for automating the Electricity energy meter reading as well as bill payment.

[4]In such automated meter system, RFID cards are issued by the electricity suppliers to individual consumers. The RFID card is unique with a code in it.

Smart Electricity meters which are incorporated with microcontrollers and RFID tags collect the information about consumed electricity units from the end consumers and then transmit this information by using wireless radio waves from the meter to a data collector. This data is processed and delivered by several methods to the server system at a central collection location.

RFID tags can be used for automating the meter readings of electricity energy meter but active RFID tags are costly and replacing current meter reading system with RFID reading system is not feasible.

C. GSM Network

[5]GSM stands for Global System for Mobile Communication. It is a wireless communication mechanism used for sending data as SMS on mobile phone. GSM network is finest than ZigBee technology, RF communication methods. While discussing about GSM based automation, a GSM module is integrated with electricity energy meter so that one can have remote access over the electricity usage. There is a computer system with a GSM receiver at the server side that contains the database acts as the billing station. Meter readings from the GSM attached electricity energy meter are transmitted to this billing station frequently and these details are updated in the database. Consumers can track the electricity usage via webpage. The monthly electricity usage and amount of bill is messaged back to the customer after processing these data on frequent basis.

D. GPRS Network

[6] GPRS stands for General Packet Radio Service which is one of the most widely used wireless communication technology.

The electricity energy meters which are automated using GPRS technology is mainly consists of three parts. First is data acquisition module, second is data transport module and third is data management module.

The data acquisition module consists of a collector and power meter group. The power line carrier communication is used to achieve the residential consumer electricity energy meter data acquisition, and transmission to concentrator of electricity data.

The data transmission module consists of a concentrator. Power consumption units' information is collected by the collector through the power line transmission to the concentrator, and then this information is transmitted through GPRS wireless communication network to the server side.

The data management module consists of the EB server, mobile VPN access equipment and other necessary hardware. It can accomplish Data storage, analysis and research of all user electricity energy meter and their electricity usage.

E. Internet Of Things

Internet of Things (IoT) is recent technology that enables commonly used objects to be equipped with microcontrollers, sensors, and transceivers allowing those objects to communicate with one another and user with the help of Internet.

[7]The electricity energy meter can be effectively automated with the use of IoT. In IoT based automated electricity energy meter, Internet is the main method of communication between the energy meter and server side.

A microcontroller is interfaced with energy meter which acts as the master controller. The microcontroller monitors every pulse of the energy meter reading and sends the measured reading information through IoT to the central server which processes these meter readings information and generates bill.

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III. THEFT DETECTION

Electricity power theft is one of the major issues of each developing country like India. Due to power theft, India loses around billions of rupees because of unbilled consumption and unlawful usage of electricity energy. According to a World Bank report, there are two types of the

Electricity power losses: technical and non-technical. Technical losses are mainly caused by power supply dissipation because of faulty transmission and distribution lines, transformers and measurement systems.

The non-technical electricity power losses consist of electricity theft, non-payment by consumers, and the errors in accounting and record keeping. Power theft losses are difficult to estimate but they run into huge amounts in India and other countries like Brazil.

In current electricity metering system, tampering can be done easily for the purpose of electricity theft and the EB server side gets notified very late. It is one of the major disadvantages of the electricity system.

There are many system designs that have been proposed for the purpose of identifying the theft attempts or any kind of tampering done with the electricity energy meter on immediately. In such systems, if any tampering is done with the electricity meter EB gets notified about it so that they can take any further action like disconnection of electricity transmission.

[8] A common approach for electricity theft is to tamper with the electricity meter installed in the residential or corporate place. There are many ways of doing this.

One of the technique is to short the ends of the meter installed at the consumer's place. By doing so, the consumer ensures that the current flowing into the house does not flow through the meter and hence the electricity meter records very low electricity usage units. Other methods include tampering with the meters so that the measurements taken by the meter are inaccurate and show lower consumption than actual.

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.

A. Theft Detection using SVM

[9]This paper presents a novel approach for detecting non-technical loss in electricity transmission. An artificial intelligence based technique SVM (Support Vector Machine) is used. SVMs are one of the best-known techniques with computational advantages over their contenders.

This method uses data mining techniques for feature extraction from old energy consumption data from consumers. The SVM method utilises the load profile data of consumers and extra qualities to identify the irregular electricity usage. As the result of this method, some classes of consumers are produced who are shortlisted to be evaluated as suspects, for the purpose of inspection o those consumers based on significant behaviour that arises due to deceptive activities.

B. Theft Detection using RF transmission

[10] SVM does not need to be linear or even have the same function form of all data obtained. Its function is non-parametric and it operates locally. SVM provides a good result out of generalised samples, if the Gaussian and Kernel parameters chosen and provides a unique solution. But the SVM technique lacks the transparency of results.

In this system, Radio Frequency (RF) transmission is used to establish the communication between the EB server side and the consumer end. RF signals are used to establish the wireless communication between EB server side and Consumer end so that server side can access the information about the measured units of consumed electricity at the consumer side. RF signals are used to make the system autonomous and reduce number of cables. When the current transits from the distributor side to the consumer end, if the total amount of power is not received by the consumer, then there is a possibility of electricity theft. Then this information about the system is displayed through the Wi-Fi space to the EB server side.

C. Theft Detection using GSM

[11] A GSM based technique for Electricity Theft Detection is proposed in this paper. In electricity meteringsystem, tampering is done basically for the purpose of electricity theft. To protect the electricity energy meter from this theft attempt a lever switch is used at the opening of the meter. The lever switch is connected to interrupt pin of the ARM processor which is configured as pull

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down. Hence closed switch applies 3.3V to the interrupt pin and opened switch drives the voltage to zero. The switch normally closed when the meter chassis is closed.

If someone tries to open or tamper with electricity energy meter, that switch gets opened and the interrupt pin gets triggered as 0V is sensed by it. The ARM processor immediately sends AT comments to GSM for sending SMS. Upon receiving SMS the authority can take further legal action against it and penalize the guilty person.

D. Theft Detection using IoT

[12]This paper presents an IoT based tamper or theft prevention system for electricity energy meter.

This paper proposed an embedded system to prevent electricity theft with the use of Internet of Things, a recent technology. This embedded system consists of a Wi-Fi module attached to electricity meter for the purpose of connectivity, a microcontroller for controlling the major functions. The Passive Infrared (PIR) sensor is being used for the purpose of sensing the tampering attempt and Solid State Relay is used for the purpose of actuation on detecting the tampering attempt. In addition to this, there is an additional facility of sending the GPS location of the meter to the distribution company portal or Electricity Board server. Thus, the proposed system will reduce electricity theft and makes the electricity system smart.

IV. AUTOMATED DISCONNECTION

Disconnection of electricity transmission is needed for one of the following reason:

If the electricity bill is not paid within given period by the consumer or if any theft attempt to electricity energy meter is identified and notified to the Electricity Board. In current electricity system, the disconnection process is time consuming and involves human efforts. An authorized person of EB visits the particular consumer's place and cut-off transmission manually. The automated system makes this process of disconnection easy and efficient by cutting-off the electricity transmission to that particular meter from distant server.

[13] It proposes a wireless ARM processor based automated meter reading & control system. In the system, an electricity energy meter has an attached ARM based Embedded System *(AES).* It contains a Utility Control Centre (UCC) at EB server side which acts as a central server. It is responsible for information processing & data exchange between server side and consumer’s place through wireless communication module. UCC is connected with ARM based Embedded System through wireless communication module. It will receive the consumed electricity units from ARM Based Embedded System. UCC can send the command signal to AES if the consumer fails to pay the electricity bill in given period of time to cut off the electricity transmission line to the consumer.

V. CONCLUSION

As discussed above Z the electricity energy meter can be automated and protected using different technologies like ZigBee, RF communication, GSM, GPRS, SVM, IoT, etc.

ZigBee is a low cost, low powered wireless networking mechanism can be used for automating and detecting electricity theft but it is less secure, involves high cost for replacement and it is not efficient for long distance communication as it requires range extender for long distance network. RF communication can be used for automating and detecting the electricity theft the meter readings of electricity energy meter but active RFID tags are costly and replacing current meter reading system with *RFID* reading system is not feasible.

GSM network is finest than ZigBee technology, RF communication methods for automating but still the problem of missing SMS will degrade the accuracy and performance.

GPRS is one of the most widely used wireless communication technologies which can easily automate the electricity energy meter reading process and detects the electricity theft on immediate basis.

SVMs are one of the best-known techniques which involve data mining techniques for feature extraction from load profile data of consumers but it lacks the transparency of results.

In IoT based automated electricity system, the accuracy of the system depends on Internet connection, quality of the sensors and other hardware used in the system.

These automated system designs will be very beneficial to our society as well as country's economic development as the electricity theft rates will be reduced. The system is efficient as it reduces human involvement, increases accuracy, prevent billing mistakes, provides theft detection.

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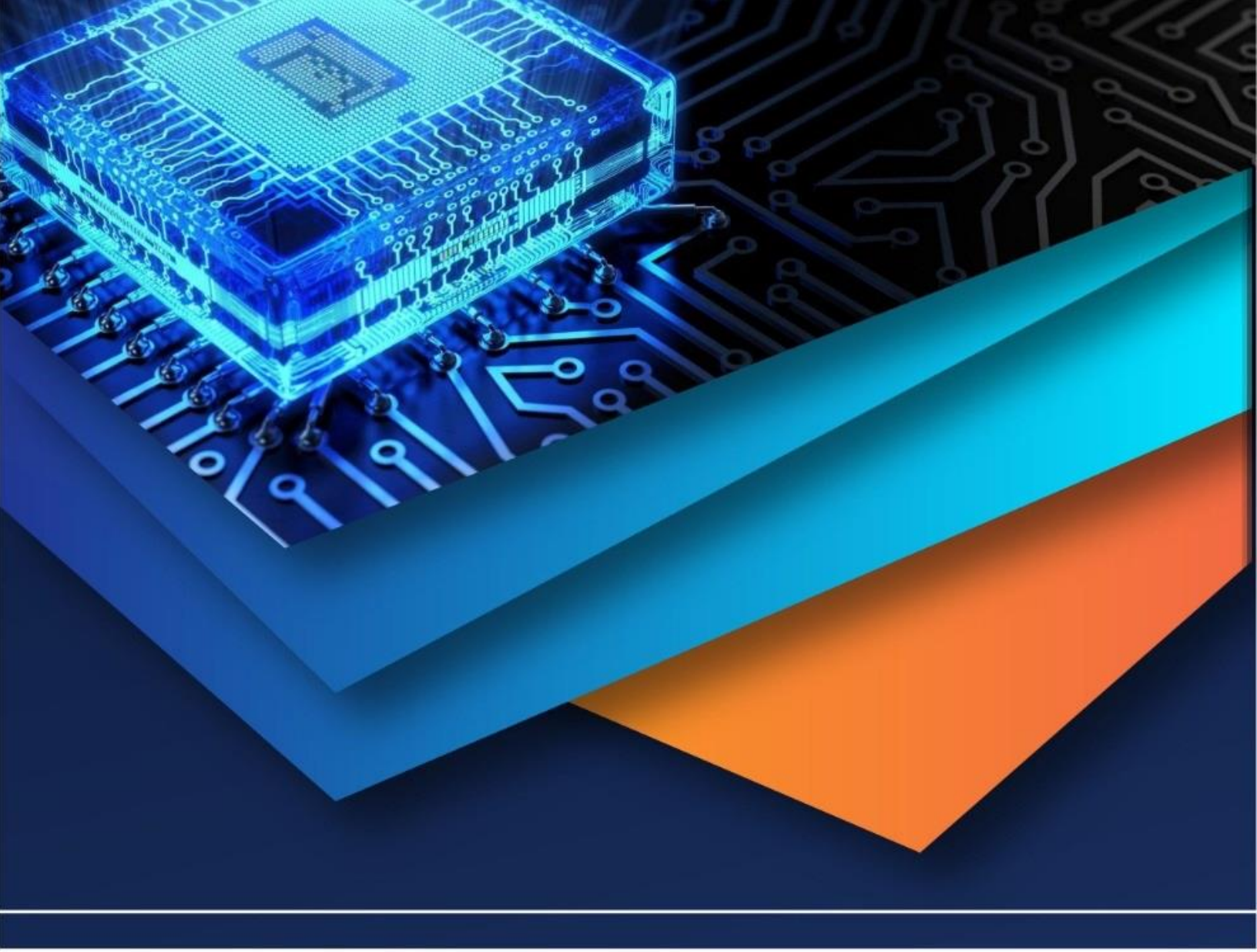
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