IoT Based Smart Energy Metering System for Monitoring the Domestic Load Using PLC and SCADA

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Abstract. The effort to obtain electricity utility meter readings and identify illegal use of electricity seems to be a very difficult and time consuming job in many other developing countries that needs a lot of effort and time. The Internet of Things energy meter reading and tracking device offers an accessible and cost effective way to transmit the energy data used by the user wirelessly and information networks to detect the unauthorized use of electricity. This proposed work aims to measure the electricity consumption of the electrical appliances in the household and it automatically generates the bill using smart meters. In addition this system can easily detect and screening the energy theft. The entire smart meters sensors have been equipped and controlled with PLC and monitored by the SCADA. The observed data will be taken from the digital energy meter and unite the system to a Wireless communication device and then passes the data to the Internet and Server. The detection of power theft will be obtained by using a sensor, it will work when any illegal usage of electricity. There is any chances of theft detection from the customer utility grid, it will automatically disconnected and enables supply again for the customer. The proposed system can handle of constantly tracking and notifying the energy supplier and the customer about the amount of units consumed. Energy usage is directly calculated and the bill is posted on the Internet through the Internet of Things network. The requirements of manual labor can be reduced by this automation.

Keywords: Smart Energy Meter, IoT, PLC, SCADA, Electricity Billing, Energy Theft detection.

1. Introduction
One of the concerns faced by the electricity sector is the control of energy. With the exponential rise in energy demand, electricity has played a prominent role in human life. Controlling and reduction of energy usage at household will be very important. This will helps the consumer to reduce the costs, carbon emissions and risk protection. Earlier the control and monitoring approaches was deals with energy meter for monitoring. But recently the conventional system has been replaced with the analogue and digital energy. The traditional energy meter system was based on the electricity board's manual
meter reading, though there is a risk of human error. Nowadays with the help of smart energy meters the entire house hold will be control and monitored smartly by using the IoT based smart metering enabled with PLC and SCADA. Most customers are not satisfied and pleased with the services of electricity suppliers in a country like India; due to conventional meter reading techniques that involve a large number of people power and long working hours to collect metering data for the payment process. Often, for different reasons, the manual payment process is slow. The conventional human operational metering method can result in inaccuracy. Electricity theft is also a difficult concern for the Indian electricity board. The Indian Electricity Board announced that almost 30 percent of its total electricity supply was lost due to the theft of electricity. The officials of the Electricity Board are also preparing to implement stringent laws such as the withdrawal of electricity supplies to homes or factories involved in electricity theft. The economic effect of theft decreases revenue from the selling of electricity and raises the need for customer overcharges. It is not enough to produce more power to meet existing energy requirements. In order to use the produced power effectively, energy usage and losses have to be closely controlled and handled. It enables objects to be managed and sensed remotely through existing communication networks by conducting the Internet of Things debate, which provides opportunities for further direct integration between both the quantum environment and computer based systems. These operations result in increased productivity, precision and economic benefits. In this report, this proposed IoT based smart energy meter reading and monitoring device monitors each household’s electricity usage and automatically generates the bill using IoT and telemetric communication techniques such as PLC and SCADA. This device also provides an efficient IoT based framework for detecting and monitoring electricity theft in household’s locations.

2. General View on PLC, SCADA and IoT Concept

2.1 About PLC

An industrial solid state computer that monitors inputs and outputs and allows logic based actions for automation or machines is a programmable logic controller. There are two fundamental parts of a Programmable Logic Controller: the CPU and the input, output interface device. The CPU governs all the operations of the Programmable Logic Controller, which can serve as both the processor and the memory device, while the Programmable Logic Controller physically linked to the other machines, the input, output mechanism and the connection between the CPU and Process of input & output. Figure1 represents the pictorial representation of PLC.

![Figure 1 Pictorial representation of PLC](image-url)
2.2 About SCADA

SCADA stands for supervisory control and Data acquisition. It is a type of process control software application programmed. SCADA is a mid control system that consists of network interfaces, input or output, communication devices, and software for controllers. In the industrial phase, this involves manufacturing, processing, development. SCADA systems are used to follow and control equipment. The SCADA device allows users to adjust the steady state for the flow and makes the warning conditions to be shown and registered in the event of a loss of flow and extreme temperatures. The performance of the loop is tracked by the SCADA system. The SCADA system is a centralized system for the Clint nodes to connect with both wired and wireless technologies. All forms of the industrial process can be completely controlled by the SCADA system devices. The figure 2 represents the pictorial representations of SCADA system.

![Pictorial representation of SCADA](image)

**Figure 2.** Pictorial representation of SCADA

2.3 About IoT architecture

The Internet of Things (IoT) is a network of interrelated digital devices, computers, items, organisms or people with digital signatures and the capacity, without any need for human to human or human to computer interaction, to transfer and exchange data over the internet. The IoT architecture is basically a system of multiple components: sensors, protocols, hydraulics, cloud computing, and levels. There are 4 levels of IoT architecture, considering its complexity. Such an amount is chosen in a comprehensive and unified network to reliably use those different kinds of components. IoT device becomes a circle where a server submits commands to sensors or actuators to do certain acts, including all steps in the IoT architecture. The Figure 3 shows the IoT architecture.
3. Proposed System Methodology

3.1 Architecture of Household Energy Monitoring Using IoT

Several investigators have been inspired by the need for appropriate energy usage and monitoring knowledge to provide creative control and monitoring strategies for the power sector. Similarly, to analyze the collected data, many organizations have Energy Management systems. The general system design for household energy monitoring using IoT can be accomplished by generalizing these procedures, as shown in Figure 4.

There are smart meters and sensors at the lower side of this architecture that can be linked via wired or wireless networks. A variety of criteria can be accomplished by smart energy meters available on the market, thereby offering a high degree of versatility in measuring and analyzing energy usage. The data collected is sent to a gateway at the middle layer and then transmitted to a local laptops and mobile devices through standard communication protocols, including wireless technology. Sensors can be much more flexibly mounted on the shop floor if wifi modems are used. Ultimately, data for review is fed into the Energy Management programme. A supervisory control and data acquisition system (SCADA) can also be combined with the data with smart metering systems.
3.2 Designing of Proposed work

The PLC unit is configured with the Automatic Data Reading unit, theft detection control unit and Wi-Fi module in the smart energy meter design. The PLC is a key component of the intelligent energy meter device that is installed at the end of the customer in order to monitor the reading of the meter, identify theft and store the data. This information is transmitted using IoT ESP3866 Wi-Fi between the user end and the energy supplier end. The Automated Data Reader module controls the meter consistently and gathers and sends the readings to the PLC. Hence the need to identify the smart meter unit remotely in a reliable way in the current situation. We have given IP addresses for each link to accomplish the characteristics of the system remotely. In this article, we focused on the detection of theft, optimal power usage, and transmission to the consumer end of the energy consumption data. The block diagram provided in Figure 5 illustrates the structure proposed.
4. Implementation of Proposed System

The user will deal with their use of energy in the proposed method by understanding their usage of energy from moment to moment. The solution not only offers two path interchanges between utility and user, but also offers distinct capacities, which are if the consumer fails to pay the power fee, the supply of energy will be shut down from the utility side and the supply of energy is reconnected until the bill is charged. In addition to the revolutionary current system to provide a warning message to the consumer power consumed for 15 days once, continuous alert message with payment information and power consumption before the payment is completed. We set a cap for each household to prevent more energy use, and if the cap reaches the methods are used to cut down the appliances automatically and manually according to user convenience. If a smart meter fault occurs, it will also submit a warning to the user. In addition this system can identify the theft of power from the user utility grid. Based on the sensor it was detected and give an alarm and alert to the user.

4.1 Progress from smart meter

From the smart meter the sensor reads the reading of the appliances which was connected. The data from the sensor will be taken as phase angle difference of the load and meters. The obtained data is given to the PLC to calculate the bill. If the loads utilized for 1 hour, the PLC convert that usage in units, from the units it can calculate the billing amount. At the same time theft of the supply can be managed from the
line supply voltage sensor, the sensor automatically detects the unknown person usage.

4.2 Progress from IoT Server

As a cloud server, Cayenne.com is used. In the server, voltage and current values are sensed by the sensor and continuously stored. It is possible to schedule notifications on a server. The theft detection system also is activated from this server notification. The automatic bill cycle will be done from the smart meters reading which enables this server to communicate with the users. From the server the data will be passed to the SCADA for real time monitoring and status of the house hold applications.

5. Real Time Implementation of Proposed System

The figure 6 shows the hardware implementation of proposed system. When the house hold loads are connected from the supply line and it was interfaced with the load control circuit and sensor as shown in the figure 6.

![Figure 6: Power Usage by days and hours Chart](image)

The output from the sensor and automatic theft circuit is combined and named as smart meters. From the smart meters it will be given to the PLC, along with the PLC the reading can be calculated and given to the server by wireless communication system. Then the bill and status of the load can be sending to user by IoT server via Mobile application. From the figure 7 the real time monitoring can be obtained from the SCADA display. By using the IoT technology the user can get the power consumption and usage status in real time from the mobile application. The figure 8 and 9 shows the power usage day and hours and consumption chart.
Figure 7: Power Consumption Chart

Figure 8: Real Time monitoring from the SCADA display.
6. Conclusion

In this paper, a smart energy meter reading and monitoring system based on IoT with PLC and SCADA was proposed. There are many important advantages to the system, such as wireless data transfer, remote monitoring and control, anti-theft machine, and lower costs. Without even any human intervention, the process will provide an easy method to earn the meter reading and identify an electricity supply theft. The consistency of wireless data transmission is enhanced by the use of PLC and wireless communication systems. The consumer can check their used unit and bill at any time by using this device on the Internet in which paper is not needed for billing, which saves paper and printing costs. The bill can be charged using the customer service system online. It helps the consumer to verify the energy usage and bill once they log in to the system, while the bill is sent monthly or on appeal to the consumer by another existing system.

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