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Smart City Billing System for Homes through IoT

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Abstract: **This paper proposed for the Smart City Billing System for Homes through Internet of Things (IoT) platform. In this paper consists of two modules, one is prepaid electricity billing and other is prepaid water usage billing by using NodeMCU system with IoT platform. First module is to minimizing the queue at the corporation / electricity board billing counters and to restrict the usage of electricity automatically, if the bill is not paid. This proposed method also supports at a system to find out the power thefts and other illegal activities. Second module is to indicate the water usage and automatic control of water flow and also prepaid water billing via IoT. It is to provide smart water supplies scheme for public and Corporation water board for automatic the control and monitoring water usage system. The proposed system adopts a totally new concept of "Electricity and Water Bill Systems for Smart City Corporation". The IoT based concept is used that the service provider and customer can continuously monitor the consumption of power (in watts) and water usage, if it reaches the minimum amount, it would automatically alert the consumer to recharge through Smart phone. In this method Arduino processor is used to monitor and control the entire system model. The implementation of IoT will help better management, conservation of energy and also in doing away with the unnecessary hassles over incorrect billing in electricity module. Further the IoT will able to incorporate transparently and seamlessly a number of different devices.**

Keywords: **IoT, NodeMCU, Smart City Billing System**

1. INTRODUCTION

Because of the rapid rise of the population density inside In the IoT model, many of the living and non-living things that encompass us will be on the internet in one form or another. Driven by the popularity of gadgets empowered by wireless technological innovation such as Wireless Bluetooth, Radio Frequency Identification, Wireless-Fidelity, Embedded Sensor, the IoT has moved out from its beginning stage and it is actually on the edge of changing the present fixed internet into a well featured upcoming Internet. Currently there are almost nine billon inter-connected gadgets and it is estimated to touch almost fifty billon gadgets by 2020. Today the world is facing such an environment that offers challenges. Energy crisis and water crisis is the main problem faced by our society. A relevant system to control and monitor energy and water usage are through the reduction of energy consumption and water usage in households. The consumers are increasing rapidly and also burden on electricity offering divisions is sharply increasing. The consumers must be facilitated by giving them an ideal solution i.e. the concept of IoT.

IoT refers to the ever-growing network of physical objects that feature an IP address for internet connectivity and the communication that occurs between these objects and other Internet-enabled devices and systems. It is a low-power wireless connectivity represents the key technology for connecting smart objects to the internet and the cloud. As a matter of fact, wireless connectivity is not dominated by one single technology. Depending on application needs or technology constraints, different hardware and software integration requirements must be considered. The main wireless connectivity schemes are Wi-Fi, Bluetooth, etc .,. Consider, a single phase digital prepaid energy meter based on two microcontrollers and a single phase energy meter IC. This digital prepaid energy meter doesn't have any rotating parts. The energy consumption is calculated using the output pulses using of the energy meter chip. Energy consumption (KWh), maximum demand (KW), total unit recharge (KWh) and rest of the units (KWh) are stored in the ATmega32 to ensure the accurate measurement. For considering that the most important contributions of other related methods is to make sure the consumer know how much they use the energy, besides this project is already converted from energy usage (KWh), so the consumer will know how much for electric bill in a month that need to pay [1-5].

In this proposed prepaid electricity billing system, the present billing system was eliminated completely and a new system namely prepaid billing system was introduced for embedded application which overcomes the drawbacks in present billing system. If this system comes in day to day life it will be useful for both the government and the public. When the user pays money; it's start counting the no of units and reduces the amount and on completion of amount, it disconnects the line automatically.

1.2 Internet of Things - Overview

IoT systems allow users to achieve deeper automation, analysis and integration within a system. IoT utilizes

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existing and emerging technology for sensing, networking and robotics. IoT exploits recent advances in software, falling hardware prices and modern attitudes towards technology. Its new and advanced elements bring major changes in the delivery of products, goods and services and the social, economic and political impact of those changes.

1.2.1 IoT – Advantages and Disadvantages

The advantages of IoT span across every area of lifestyle and business. Here is a list of some of the advantages that IoT has to offer :

- Improved Customer Engagement
- Technology Optimization
- Reduced Waste
- Enhanced Data Collection

Disadvantages

Though IoT delivers an impressive set of benefits, it also presents a significant set of challenges. Here is a list of some its major issues −

- Security
- Privacy
- Complexity
- Flexibility
- Compliance

1.2.2. Applications of IoT

IoT functions in a similar and deeper way to current technology, analytics and big data. Existing technology collects specific data to produce related metrics and patterns over time, however, that data often lacks depth and accuracy. IoT improves this by observing more behaviours and analyzing them differently. Some of major application of IoT as follows:

- Environmental Monitoring and Air & Water Pollution
- Intelligent Product Enhancements
- Dynamic Response to Market Demands
- Emergency Care
- Automobile Sector and Parking System
- Building / Housing and Automobile Applications
- Education Organizations

12.4 Government Applications

IoT supports the development of smart nations and smart cities. This includes enhancement of infrastructure previously discussed defense and also the engineering and maintenance of communities.

City Planning and Management

Governing bodies and engineers can use IoT to analyze the often complex aspects of city planning and management. IoT simplifies examining various factors such as population growth, zoning, mapping, water supply, transportation patterns, food supply, social services and land use. It gathers detailed data in these areas and produces more valuable and accurate information than current analytics given its ability to actually "live" with people in a city. In the area of management, IoT supports cities through its implementation in major services and infrastructure such as transportation and healthcare. It also aids in other key areas like water control, waste management, and emergency management. Its real-time and detailed information facilitate more prompt decisions in contrast to the traditional process plagued by information lag, which can be critical in emergency management. Consumers benefit personally and professionally from the optimization and data analysis of IoT.

2. PROPOSED SYSTEM

2.1 Corporation Billing System for Smart City using IoT

The proposed system is used for monitoring and controlling the amount of power consumption and water usage that the consumers are using with the help of the energy meter and water meter using NodeMCU (ESP 8266EX).

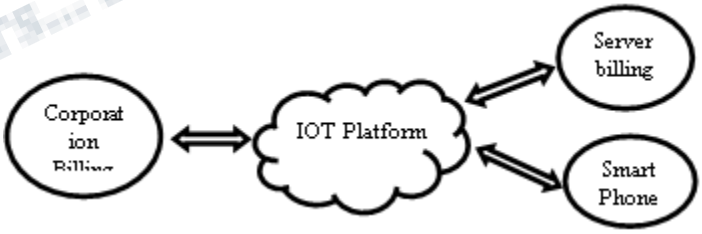

Figure 2.1 System Overview

2.1.1. IoT platform

Wi-Fi is one of the candidate technologies for the IoT. It natively offers TCP/IP, the networking protocol that today connects billions of devices world-wide. Things can be connected to the internet through existing Wi-Fi access points in a growing number of private houses and public buildings including schools, hospitals, offices and industries. These trends push connectivity in applications such as:

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Vol 4, Issue 7, July 2017

- Smart Home and Smart Building: all home appliances control.
- Industrial: manufacturing control, maintenance, diagnostics, and M2M data flow.
- Medical: M2M communication and fitness equipment.
- Energy management: metering systems
- Security: surveillance, presence-detection and alarm actuators.
- Smart City: smart metering, asset tracking, etc.
- Smart Car: GPS and smart electric-vehicle charging stations

2.1.2 Server Billing

In a technical sense, a server is an instance of a computer program that accepts and responds to requests made by another program, known as a client. Servers are used to manage network resources. Consider a user will setup a server to control access to a network, send / receive e-mail, manage print jobs or host a website. There are many classifications of servers those are Cloud server, Database server, Dedicated server, File server, Print server, Proxy server, Standalone server, Web server, Billing server etc. Billing server in the sense, a server is a computer program that is based on the energy meter and water flow sensor readings which accepts and responds to requests made by program.

3.2 HARDWARE DESCRIPTION FOR ENERGY MODULE AND WATER MODULE

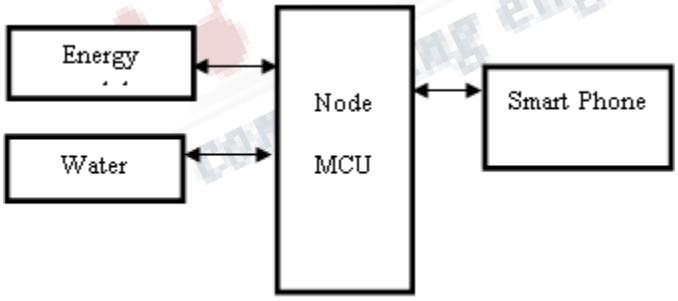

Figure 3.1 Block Diagram for corporation billing system

3.2.1 NodeMCU (ESP8266EX)

ESP8266 (presently ESP8266EX) is a chip with which manufacturers are making wirelessly networkable micro-controller modules. ESP8266EX is among the most integrated Wi-Fi chips in the industry. Measuring just 5mm x 5mm, ESP8266EX requires minimal external circuitry and integrates a 32-bit Tensilica MCU, standard digital peripheral interfaces, antenna switches, RF balun, power amplifier, low noise receive amplifier, filters and power management modules - all in one small package.

3.2.2 Single Phase Energy Meter

The meter having capable of recording & displaying energy in KWH & demand in KW for single phase two wire A.C. loads respectively for power factor range of Zero lag – unity – Zero lead. Meters should have facility/ capability of recording tamper information.

3.2.3 Optocoupler

4N35 is an optocoupler integrated circuit in which an infrared emitter diode drives a phototransistor. Optocouplers also provides interface between different voltage levels. The input current of an optocoupler can be photo transistor, LDR, photo diode and LASRC. When the input voltage of LED is forward biased, the LED emits light, this transmitted light turns ON photo sensitive device which produce nearly the same voltage at output. It is typically used to prevent unwanted feedback into an optical oscillator, such as a laser cavity.[6-8]

3.2.4 Relay

Relay is an electromagnetic device which is used to isolate two circuits electrically and connect them magnetically. They are very useful devices and allow one circuit to switch another one while they are completely separate[9].

3.2.5. Water flow Sensor

Water flow sensor consists of a plastic valve body, a water rotor, and a hall-effect sensor. When water flows through the rotor and rotor rolls. Its speed changes with different rate of flow. The hall-effect sensor outputs the corresponding pulse signal. The physical principle at work is Faraday's law of electromagnetic induction.

4.1 SOFTWARE IMPLEMENTATION

4.1. Data Is Transmitted Over the Public Internet

Technically, the Internet is those networks covered by TCP/IP protocols. These include those for the secure supply chain and dealing systems of the aerospace and financial services industries. In practice, however, what most consumers, academics and small firms have access to is only any-to-any packet switching via the following methods:

- Hosting

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- Caching
- Mirroring

4.1.2 Internet of Things Communications Models

From an operational perspective, it is useful to think about how IoT devices connect and communicate in terms of their technical communication models. The discussion below presents this framework and explains key characteristics of each model in the framework.

- Device-to-Device Communications
- Device-to-Cloud Communications
- Device-to-Gateway Model
- Back-End Data-Sharing Model

4.1.3 IOT ARCHITECTURE

The basic building blocks of IOT architecture are sensory devices, remote service invocation, communication networks and context aware processing of events. An IoT creates the inter connectivity among the devices that are distributed over an environment. The architecture of IoT has to link the physical and virtual components together by considering the design failure recovery and scalability. Because of the wide spread usage of smart phones, mobility and dynamic change of location are considered to be integral parts of IoT systems and the architecture should posses proper level of adaptability to handle dynamic interactions with the ecosystem. The IoT architecture (IoT-A) centers on network architecture with an objective of "The European light house integrated project addressing the internet-of-things architecture". The IOT-I architecture center on the promotion of IoT solutions, with an aim to achieve objectives like "creating a joint strategic and technical vision for IoT in European and contributing it for the creation of economically sustainable and socially acceptable environment which can be utilized for IoT technologies and R & D activities.

The architecture consists of service layers, presentation layers. All the above components are included in the architecture because of properties like device management, security, privacy enforcement and unique identification of objects.

Depending on the features of SOA, API, the architectures are given as,

1. SOA-based architecture
2. API-oriented architecture.

4.2 Coding:

Arduino Software

The Arduino integrated development environment (IDE) is a cross-platform application written in Java, and derives from the IDE for the Processing programming language and the Wiring projects. It is designed to introduce programming to artists and other newcomers unfamiliar with software development. It includes a code editor with features such as syntax highlighting, brace matching and automatic indentation, and is also capable of compiling and uploading programs to the board with a single click. A program or code written for Arduino is called a "sketch". Arduino programs are written in C or C++.

Arduino boards can be controlled using an implementation of Wiring, which is a version of Processing developed specifically for electronic I/O. Arduino looks like Processing, but is actually built in C, so there are a few differences to look out for. Arduino is a standard window application and starts by clicking on the program icon.

5.1 RESULTS AND DISCUSSION

Corporation billing system using IoT consists of two modules, one is electricity module and other is water module. Electricity module

In electricity module single phase static energy meter, optocoupler and NodeMCU are used. From energy meter magnetic pulses are generated. Those pulses are not given directly to NodeMCU. So optocoupler is used to read these pulses to NodeMCU at D2 pin. NodeMCU model consists of 16 digital I/O pins. For D2 pin the output from optocoupler is given. Then it reads the pulses, based on the no of pulses the meter readings are calculated. Based on the usage of electricity, the units are displayed on the smart phone. This can be monitored and controlled through our mobile phone using IoT. Based on the usage of electricity the reading is displayed on mobile phone. The electricity module can be continuously monitored and controlled by mobile phone through IoT at wherever place is needed.

Figure 5.1 Displaying readings in Energy Module

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Figure5.2 Displaying units of Energy Module in Smart Phone

Sl. No	Domains	Energy Units	Price
1	Domestic (0-50 units)	KWh	1.45/-
2	Domestic (51-100 units)	KWh	2.6/-
3	Non-Domestic /Commercial (0-50 units)	KWh	5.4/-
4	Non-Domestic /Commercial (51-100 units)	KWh	7.38/-
5	Industry	KWh	6.08/-

Table 5.1 Electricity Board Tariff of A.P Transco

Figure 5.1 & 5.2 reveals that the energy consumption are recorded in energy meter and with the help of Optocoupler the value convert and send it to NodeMCU. The NodeMCU calculated the unit into consumption charges in rupees and transmitted the value to IoT based billing server. After that the Smart Phone immediately received information from NodeMCU / Billing Server. The Smart Phone having a prepaid recharge option by using this the customer can recharge the amount. The readings are noted based on tariff range[11-16]. Table 5.1shown the AP Transco tariff ranges are taken as example.

Water module

Figure 5.3 shown the Display of Water module. It is consists of relay, water pump, water flow sensor and DC supply. Based on the usage of water the readings are displayed on smart phone through IoT, monitoring and controlling the water supply can be done in mobile itself[17].

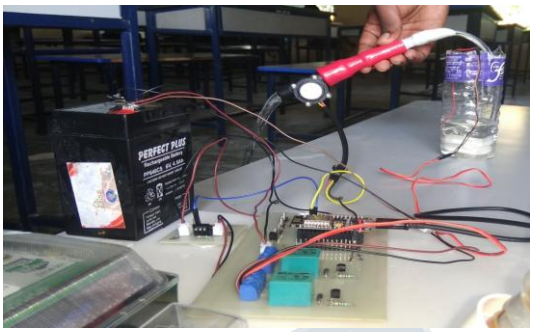

Figure 5.3 Displaying of Water Module

Figure 5.4 Displaying units of Water Module in Smart Phone

Figure 5.4 portrays that the water flow sensor detected pulse converted into the litres and NodeMCU unit calculated the Water bill and the information transmitted to the Smart Phone through IoT platform. Further the smart phone are monitoring and controlled Water pump and water tank level with the help of wireless sensors. The readings are noted based on rural and urban water resource management tariff range of Government of Andhra Pradesh as shown in Table 5.2.

Sl. No	Category	Units in Kiloliters (per day or person)	Price
1	Domestic	0-15	40/-
2	Domestic	16-100	70/-
3	Domestic	101-200	100/-
4	Industry	0-15	50/-
5	Industry	16-100	80/-
6	Industry	101-200	120/-

Table 5.2 Water Tarrif of A.P

6. CONCLUSION

The Corporation Billing System gives well-groomed solution for smart corporation billing and forecasting the usage of energy and water for Smart City are accomplished with the help of IoT platform. In this proposed system continuous monitoring and controlling the consumption of power (in watts) and water (in liters) with billing is done. If the consumption of power and water reaches the minimum amount, it would automatically alert the consumer to recharge through smart phone. In this work NodeMCU is used to monitor and control the entire system model. The implementation of IoT will help better management, conservation of energy and water. This system eliminates the human involvement for Corporations / Municipality Monitoring. The Billing system can continuously monitor the consumption of power (in watts), Water in liters, it would monitor through smart phone. There is no need to go at the energy/water meter for checking the readings automatically the values will be displayed on the smart phone. The Consumer can see that how much power and water will be used and also displays that what is the amount for that power and water in terms of rupees.

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