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Smart Power Monitoring and Control System through Internet of things using Cloud Data Storage

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Abstract

Background/Objectives: Lack of resources established in the present world is initiating everyone towards energy efficient technologies.Among all these resources, power is one which needs to be monitored and controlled as per the need since electricity consumption is increasing day-by day. **Methods/Statistical Analysis:** Internet of things reduces the effort of human by introducing machine to machine interaction. This work has been designed to implement smart power monitoring and control system through IoT using cloud data storage. **Findings:** Power consumed by various appliances is monitored through an ARM based controller interfaced to Hall Effect current sensors and stored in a cloud data base known as Xively. Power control of home appliances is achieved through actuators such as relays which can be controlled by client with the help of a web server. The web server is designed using Hyper Text Transfer Protocol for communication between client and server by establishing Remote Procedure Calls between client and server. **Conclusion/Improvements:** The designed system enables client to monitor and control the appliances at home from anywhere availing the IoT features of the designed system thereby reducing the wastage of energy.

Keywords: Energy, Home Automation, IoT, Xively

1. Introduction

Electricity is the most basic need of everyone in this modern world. Energy consumption graph is increasing day by day where as the resources of energy are diminishing parallel. Usage of power is growing drastically paving the way for energy efficient technologies and digging for renewable energy sources. Since prevention is better than cure awareness of energy consumption should be brought into every place before resources get extinguished. Industrial users consume about 37 percent of the total energy, personal and commercial transportation consumes 20 percent whereas residential appliances consume 11 percent; and commercial uses amount to 5 percent of the total energy and remaining 27 percent of the world's energy is lost in energy transmission and generation.

The designed system will help in reducing the energy wastage by continuously monitoring and controlling the electrical appliances. Among all the microcontrollers, mbed is selected because of the features it has like simplicity, online compiler, comfortable start-up and peripheral libraries. Since mbed has 10/100MBit Ethernet compatibility, it can be interfaced to Ethernet modem in order to implement IoT. The monitored values from sensors can be continuously stored and updated in a cloud database. There are many open source cloud platforms such as Ubidots, Xively and Thing Speak etc. for several dashboard devices. Xively provides libraries and BSP files to mbed. This is the reason for choosing Xively as storage

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platform for monitored data from current measuring sensors. Controlling of the devices is the other task that could be done to save energy. Relays can be used as actuators in order to turn on and turn off the appliances as per the needs. Automation system online makes user to operate the system even when user is not in vicinity of the automation system. In this context, IoT concept has been initiated. IoT represents integration of devices through internet which implies that the devices utilize IP(Internet Protocol) address as unique identifier. When interfaced to Ethernet, each mbed generates unique IP address. Depending upon the necessity and number of rooms' present in house, user can provide controllers to each room.

Steven Lanzisera[1] proposes an energy-efficient solution using new concept of CPS (Communicating Power Supplies) to facilitate the information transfer about energy and control the information between the device and building management system. The components of CPS are an mbed controller to control all the information and a RF transceiver to communicate to user. All the data obtained can be stored in the cloud data base using IoT platform. The system is tested on three devices i.e. Television, video player and LED light. CPS devices are integrated into the product to provide native controls and automatically include product identity information.

QinranHu[2] initiated a hardware system that consists of Smart Home Energy Management System (SHEMS) including applications such as communication, sensing technology and a machine-learning algorithm. SHEMS includes sensors which are used detect human activities and with the help of this data, machine-learning algorithm is executed consequently. This execution reduces the total electricity bills for consumers without any need of human's presence.

Mansour H. Assaf[3] introduced home control and security system based on the field programmable array. The FPGA used is Nios development board cyclone-II edition which provides hardware platform for developing embedded systems based on Altera cyclone-II devices.The model of the proposed system is designed and the correlation of software and hardware is carried out. The logics for controlling are designed in FPGA and communicated to the user through web server. The web server is created by using HTML or java based script. User alerts are given through web server designed in PHP and thereby placing switch modules and controlling them through controller provides the entire security system.

Dae-Man Han[4] instigated smart home interfaces and device definitions to allow interoperability among ZigBee devices produced by various manufacturers of electrical equipment, meters and smart energy enabling products. ZigBee can be utilized for transferring the information about the power and energy of home appliances. For monitoring the solar panels, power-line communication is utilized. This protocol establishes the wireless network, based on the Kruskal's algorithm value measured from the RF radio.

Jinsoo Han[5] proposed a photovoltaic system management to improve home energy management based on PLC that consists of PLC modem, Renewable Energy Gateway (REG) and smart device source. The PLC modems communicate with the REG through the power line which transmits the DC power generated by PV modules to the grid-connected inverter. The REG stores and processes the received status value. The smart device application provides the status of the entire PV system and this method allows clients to limit the failures and quickly fix them.

2. System Architecture

2.1 Components Required

2.1.1 Hardware Components

The hardware of the system includes mbed microcontroller (LPC1768), Hall Effect current sensor, Ethernet Modem, RJ45 Ethernet cable, Ethernet break outboard, 2Channel relay and appliances such as 10W bulb and 12v DC fan. Relay needs 12v power supply.

2.1.1.1 mbed Controller

The NXP LPC1768 microcontroller is chosen for this application since it provides peripheral support for Ethernet which helps in implementing IoT part of the system. mbed has library files built for Xively (cloud platform) which helps to monitor the values of sensors through Internet. It consumes low power,it is also of low cost and it can operate up to 100MHz. It facilitates the Ethernet and USB to run at the same time without affecting the performance.

2.1.1.2 Groove Electricity Sensor

In order to measure the power consumed in each appliance, current should be monitored. To serve this purpose Electricity sensor module based on the TA12-200 current transformer that has capability to change large alternating current into small amplitude. This sensor can measure alternating current up to 5A.

2.1.1.3 Two Channel Relay

Relay can control any appliance using the magnetic circuit present in it. A two-channel relay can basically control 2 appliances. It needs 12v power supply. When relay gets triggered it opens the magnetic circuit inside and turns off the device. 2 channel relay can control two devices at a time. In this application, a two channel relay is used in each node.

2.1.1.4 Ethernet Router

Zyxel NBG-419N v2 wireless router is used for LAN connection in order to provide Ethernet interface to mbed. It incorporates 802.11n standard.

2.1.2 Software

2.1.2.1 mbed Online Compiler

The mbed Software Development Kit (SDK) facilitates the mbed C/C++ software platform and also provides an API-driven approach to microcontroller coding.

2.1.2.2 Xively

Xively is software which enables the cloud data storage. It is open source software and has libraries for mbed.

2.2 Design Diagram

The proposed system is for scenario in which there are two rooms. In each room, an mbed microcontroller and sensor-actuator units are designed. Both the controllers are connected to the Internet using Ethernet router. Refer Figure 1 for the same.

3. Implementation

3.1 Flow Chart

The execution flow in Figure 2 and Figure 3 starts with checking the Ethernet connection. If Ethernet connection is proper, then IP address gets displayed in serial terminal. If there is problem with Ethernet it shows error. After checking Ethernet connection, server port configuration is verified. If there is some problem error message appears in serial terminal. If server port configuration is proper then the server runs, TCP socket gets connected and RPC is established. User can give options in web server to control appliances. PPC commands internally invoke the microcontroller actions. When the TCP connection gets established, the HTTP server starts running. Then the HTML5 code also gets initiated. When the IP is given in the URL the background HTML5 code runs and webpage is displayed. In that when user gives signals the corresponding RPC gets initiated and the action will be performed by the microcontroller as per the signal given by the user.

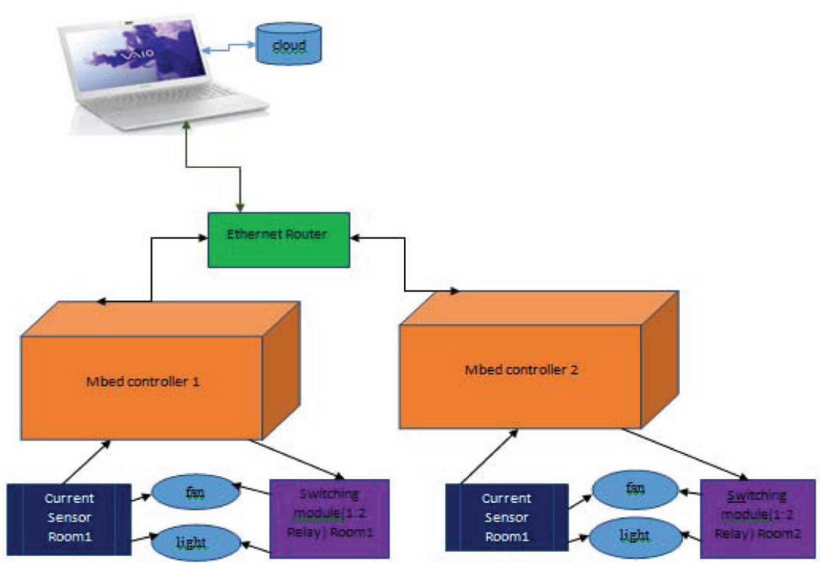

Figure 1. Proposed system.

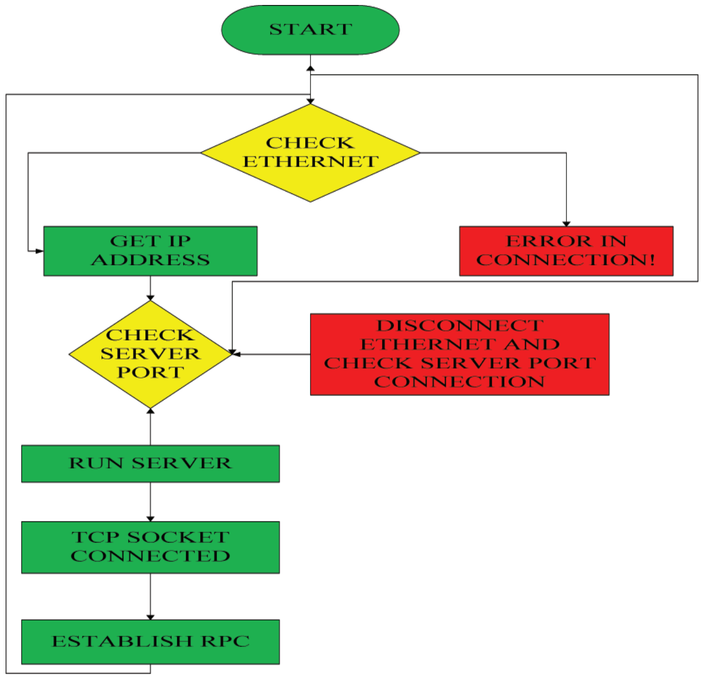

Figure 2. Flow Chart.

3.2 Xively Implementation

Read the feed id and keep the feed data stream count and feed data stream data point count as 1. The orientation of data stream is pointed to the feed data streams and copied to the Xively data stream. Current orientation points to the orientation of data streams. Cosm library is created. API key, HTTP, feed id is given to the Xively context. Now set the value to current orientation buffer. Send all the values to Xively server. Update the values in Xively. The flow of execution can be seen in Figure 3.

4. Results

4.1 Experimental Setup

The entire system is set up as shown in the Figure 4. The system consists of two nodes. Each node consists of an mbed interfaced to sensors and relays. Two appliances i.e. a 10 W LED bulb and 12v DC fan are controlled using two channel relay.

4.2 Monitoring the Current Values in Xively

The measured data from the sensors can be stored in Xively database. For each channel to be measured Xively gives a feed id and API key. Feed id and API key are provided to mbed and then code is executed in order to update the values in Xively. The outputs in Xively can be seen in Figure 5.

4.3 Client-server Communication

The client-server communication is done by using RPC (Remote Procedure Calls). HTTP is the communication protocol used. The commands and arguments are passed in between client and server. The output of sending and receiving data can be figured out in Figure 6.

4.4 Web Server for Controlling Appliances

When mbed is interfaced with Ethernet, it generates a unique IP. So in this system two different IP's are generated by two different mbed controllers. The webpage is designed so that when IP is provided in the URL the control page as shown in Figure 7 opens and to user can control lights and fans by selecting button on or off. Internally when user selects the on or off button internally, RPC commands are initiated for controlling channels of relays.

5. Conclusion

The results show that when tested with designed system, the average energy consumption of the appliances is reduced since they are turned off when unused. The graph shown in Figure 8 shows the energy consumption hourly

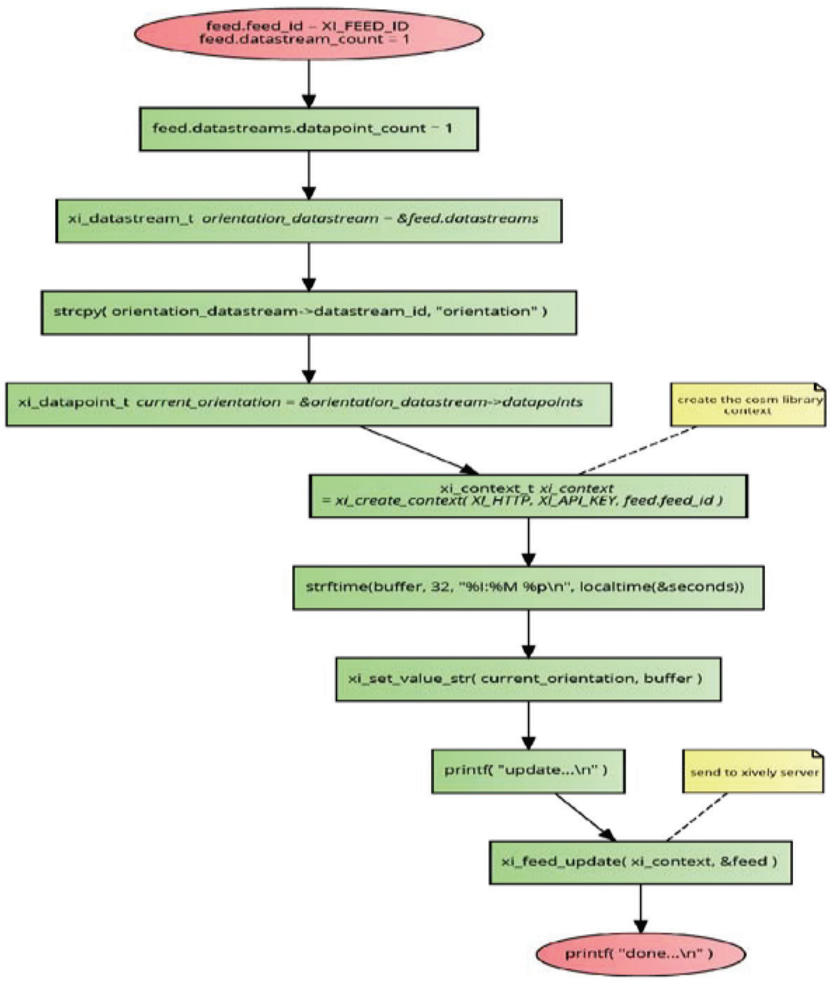

Figure 3. Execution flow of Xively.

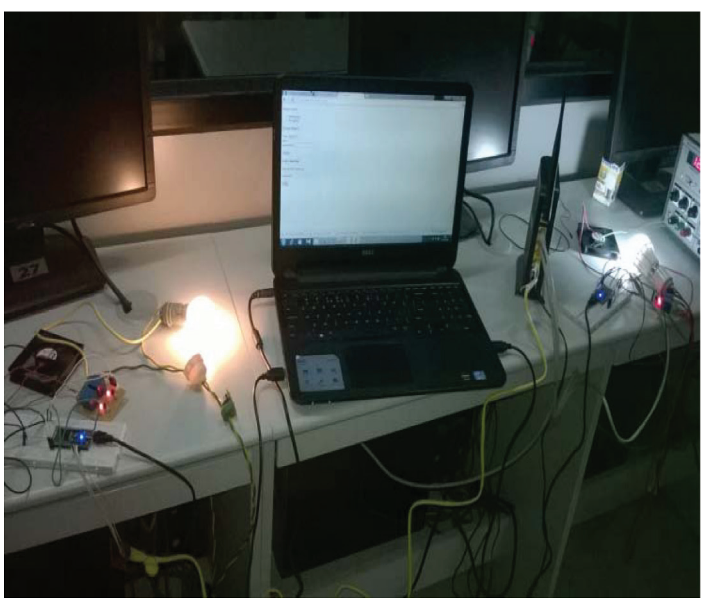

Figure 4. Setting up the entire system.

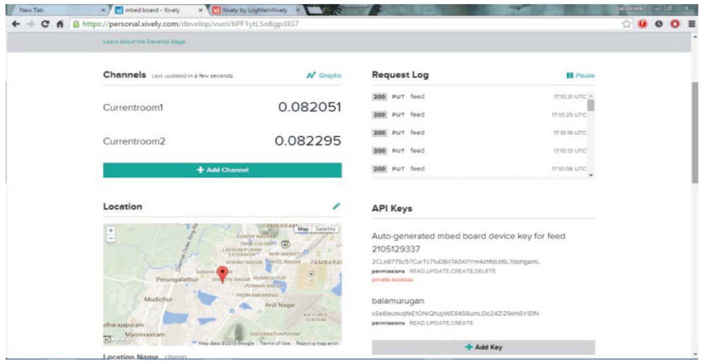

Figure 5. Xively output.

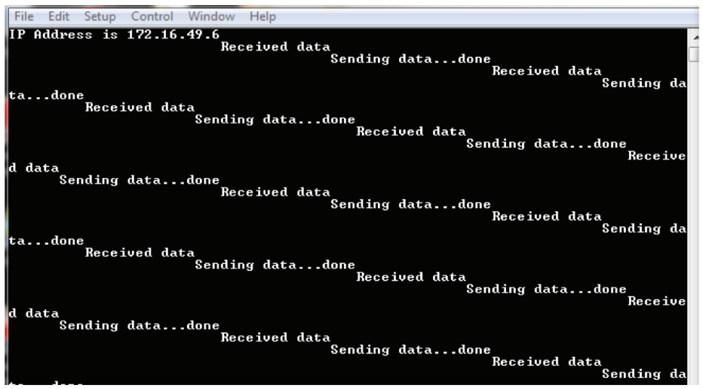

Figure 6. Output in Teraterm.

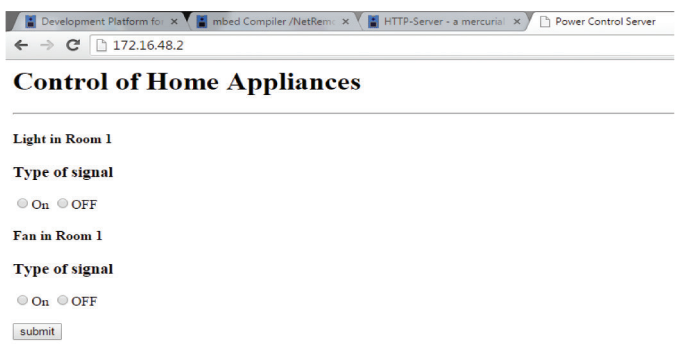

Figure 7. Control through web server.

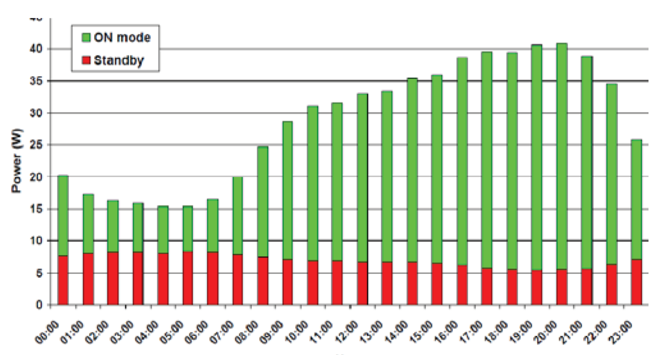

Figure 8. Hourly energy consumption graph in test system.

by home appliances in a single day. By employing the proposed automation system, the total energy consumption is reduced. On a whole in a year up to 15 percent of energy can be saved in residential building by implementing Smart Power monitoring and control System through IoT.

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