An IoT Based Monitoring and Control System For Environmental Conditions and Safety In Home

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***Abstract*—With the trend going on in ubiquitous computing, everything is going to be connected to the Internet and its data will be used for various progressive purposes, creating not only information from it, but also knowledge and even wisdom. In this paper, we have reported an effective implementation for Internet of Things used for monitoring and controlling regular domestic conditions by means of low cost ubiquitous sensing system. The description about the integrated network architecture and the interconnecting mechanisms for reliable measurement of parameters by smart sensors and transmission of data via Internet is being presented. The environmental sensing system is also able to corresponding loads based on the decisions taken by remote user or server. The longitudinal learning system is able to provide self-control mechanism for better operations of the devices in monitoring stage. Along with the environmental conditions system is also able to provide home security based on alarms input. The paper proposes a framework for effective monitoring and control with MQTT as application layer protocol between server and users as well as server and Gateway. The system incorporates ZigBee for communication between Wireless Sensing Nodes and Gateway.**

***Keywords*— Internet of Things (IoT), Wireless Sensor Network, Home Automation, ZigBee, Energy Management, Message Queuing Telemetry Transport(MQTT)**

I. INTRODUCTION

It has been more than fifteen years since the term Internet of Things (IoT) was introduced to the public. However, despite the efforts of research groups and innovative corporations, still today it is not possible to say that IoT is upon us. This is mainly due to the fact that a unified IoT architecture has not been yet clearly defined and there is no common agreement in defining protocols and standards for all IoT parts. Internet of Things (IoT) is an ideal emerging technology to influence the internet and communication technologies. Simply "Internet of Things" connects living and non living "things" through "internet". Traditionally in the object oriented paradigm everything in the world is considered as an object, but in the IoT paradigm everything in the world is considered as a smart object, and allows them to communicate each other through the internet technologies by physically or virtually. IoT allows people and things to be connected Anytime, Anyplace, with anything and anyone, by using ideally in any path/network and any service.

II. OBJECTIVES OF IOT

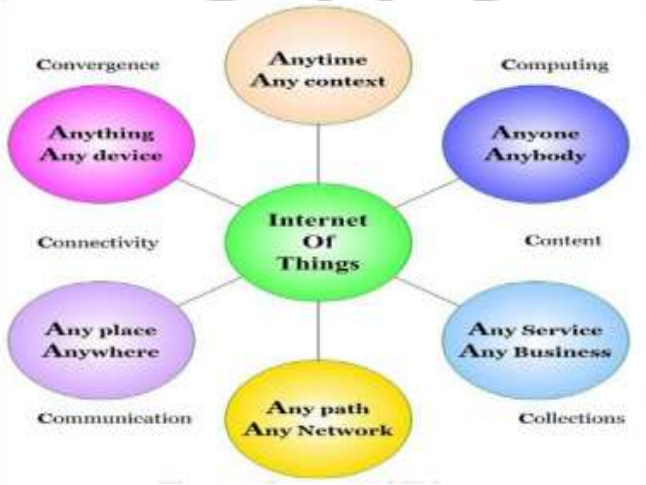

Figure 2.1 Objectives of IoT

Fig.2.1 describes the coupling of C"s and A"s. That reveals, people and things can be connected Anytime, Anyplace, with Anything and Anyone, ideally by using in Anypath/network and Any service. This implies addressing elements such as Convergence, Content, Collections (Repositories), Computing, Communication, and Connectivity in the context where there is seamless interconnection between people and things and/or between things and things so the A and C elements are present and tightly coupled. An effective low-cost and flexible solution for condition monitoring and energy management and safety in home is proposed. The basic operations include remote management and control of domestic devices such as electric lamp; water heater

etc., unobtrusive monitoring of domestic utilizations and providing ambient intelligence to reduce the energy consumption through IoT technology are the key functions of the developed system. This will support and reschedule the inhabitant operating time according to the energy demand and supply. Also safety aspects such door open, lockers will also monitored and alarms will be raised. The novelty of the system is the Internet working mechanisms, which are practicable to integrate with co-modules like intelligent home monitoring systems for wellness determination of inhabitants. ZigBee is employed as the basic indoor networking technique of wireless smart-home sensor network. ZigBee which is characterized by its short distance application, simple structure, low power consumption and low rate, becomes the standard that IEEE groups designed for family short-distance wireless connectivity. By using IEEE 802.15.4 specification as MAC and PHY standards, ZigBee technology is quite suitable for indoor home network [3]

III. PREVIOUS WORK

With the advancements in Internet technologies and Wireless Sensor Networks (WSN), a new trend in the era of ubiquity is being realized. Enormous increase in users of Internet and modifications on the internetworking technologies enable networking of everyday objects. Paper [2] explains about this.

Paper [3] and [4] says "Internet of Things (IoT)" is all about physical items talking to each other, machine-to-machine communications and person-to-computer communications will be extended to "things". In recent years several research activities are in progress for evolution of IoT, IEEE also formed a community for IoT to formalize standards and publish research work. Paper [5] to [6] talks about this. Most of the research activities related to IoT are confined to management of resource constraint devices [7], and different mechanisms of interconnection [8, 9]

There are several examples of intelligent home automation or "Smart Home Monitoring" in research labs around the world, such as the GatorTech Smart House [10], Casas Smart Home [11], iDorm [12], Georgia Tech Aware Home [13], Place Lab [14], etc. To date, there has been no complete development of a monitoring smart home of commercial perspective, nor any investigation into how such a house is perceived by either the inhabitants or their careers. The smart homes designed so far are for different purposes such as information collection and decision support system for the wellbeing of the inhabitants [15, 16], storing and retrieving of multimedia data [17] and surveillance, where the data is captured from the environment and processed to obtain information that can help to raise alarms, in order to protect the home and the inhabitants from burglaries, theft and natural disasters [17].

Jayavardhana Gubbi, Louis Coetzee et al. [18, 19] describes the origin and vision of IoT and the paper investigated and analyzed applications, challenges and future trends of IoT. Chonggang Wang et al. [20] broadly discussed the state of the art of IoT. Yin Jie proposed a novel idea of applying IoT technologies to smart home [21]. Alberto M.C et al. proposed an architecture for accessing smart home devices through web clients. The paper uses LinkSmart Middleware layer to create interface between web server and embedded system unit. The embedded system physically connects with web server and act as a gateway to the devices [22].

IV. AIM AND OBJECTIVES

A. Aim

The proposed paper work aims to design and develop a low cost smart home system in which Wireless Sensing Nodes will be placed at homes to collect and control environmental monitoring data and security data. This data will be transmitted to web based server using IoT protocols at application layer. The user will able to see and control the data through a web page or mobile application.

B. Objectives

1. Following parameters will be sensed:
   - Hot water system parameters (Temperature and Current).
   - Indoor Temperature and Light Intensity.
   - Door Locks.
   - Safety locker status.
   - Water Pump Parameters (Level and Current).
2. Network of sensor nodes will be formed using Wireless ZigBee Technology.
3. ZigBee – GPRS Gateway Will be developed which will support MQTT to communicate with remote server.
4. Develop web based client software to monitor and control home parameters from remote end.

V. PROPOSED WORK

The proposed project work can be divided into following units

5.1 Sensing Nodes:

We need to use different types of sensing for effective data management on the IoT networks. These units will responsible for collecting the data and send the data to IoT Gateway over ZigBee. As the sensing nodes needs to sense the analog signals and may need to control the devices connected to them, the nodes will contain digital microcontroller with ADC. The controller will communicate to ZigBee over UART.

5.2 *IoT Gateway:*

The Gateway will have ZigBee aggregator on board to co-ordinate between other nodes. This gateway will convert information contained into ZigBee packets and send it to central server over TCP-IP protocol. An efficient IoT protocol such as MQTT will be used for application layers to reduce data usage and power consumption. The Gateway will use cellular technology (3G/GPRS) to communicate over central server.

5.3 Central Server and Web Interface

The central server will responsible for storing the database. Also it will co-ordinate between the user devices and IoT gateway at home. Web Page will be hosted on central server. Home owners can log-in to the web interface and monitor/control the home appliances. Home owners will get notifications from central server when alarms received from the home IoT gateway.

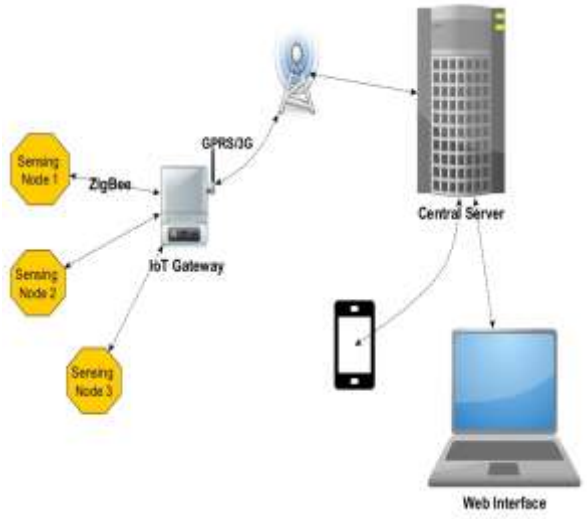

Fig. 5.1 : Block diagram

VI. SOFTWARE DESIGN

6.1 Sensor Node Initialization

Programming of sensor nodes is done via Arduino IDE. Microcontroller on the Arduino board comes with on chip boot-loader, so that we can program the controller over simple serial interface.

The first step is to properly set the clock frequency of the microcontroller. Arduino boards works on 16MHz clock frequency. Once the clock frequency is initialized controller switches to work on external oscillator.

After that UART module needs to be initialized to work on proper baud rate and parity settings to become compatible with XBee module. The UART settings used as follows:

Number of data bits:8.
Parity: None.
Number of stop bits: 1.
Baud Rate: 9600.

Once The UART is initialized the next step is to enable ADC.It is done by setting ADEN bit, selecting ADC channel and enabling the ADC interrupt.

Last step of initialization is to initialize the Xbee Module by Setting the PAN ID, Channel and MY Address. To do this initialization we have to move module to AT commands mode .Once initialization is over, we bring back module to transparent mode.

6.2 Sensor Node Main Loop

A sensor will continuously collect the sensor the data with the help of ADC using ADC interrupt. In the main loop the ADC will first check if any data received from XBee module over UART. Once complete frame received from Xbee module that frame is analyzed and validated.

After reception of the query from the gateway, the sensor data is collected. The sensor data is encapsulated into response frame. This response frame is then transmitted over UART.

Once the response frame transmission is complete control again waits for next query from the master.

6.3 Gateway Initialization

For Gateway node we need to initialize two UART for serial communication with XBee and SIM800 Modem. ATMEGA328P controller comes only one hardware UART, due to this limitation we need to use two digital I/O's for serial communication.

UART settings for Xbee are same as that of for nodes. UART settings for modem are as follows:

Number of data bits:8.
Parity: None.
Number of stop bits: 1.
Baud Rate: 115200

After that we need to initialize the modem with the help of AT commands. First we turn OFF Echo of the modem by using ATE0 command. After that we disable the incoming call as there is no need of voice call facility.SMS mode is set as Text mode.

Once basic modem initialization is over then we check whether SIM card is inserted and detected by the modem or not .Once SIM card is detected then we wait for SIM to register to its network. As SIM800 comes with Auto registration facility we don't need to select the network operator for registration.

We first check for GSM Network registration and then for GPRS network registration. If both networks are registered successfully then we go for further processing.

If any error occurred during checking the registration then we retry it. After five such retries we reset the modem to re-initiate the registration process.

6.4 Gateway main loop

Main role of the Gateway is to collect data from the node and send it over GPRS. Also gateway is responsible for forwarding the control commands received from remote end.

To do this a periodic timer is set to collect data from sensor nodes. Once this time period over controller prepares query and send it over XBee module. After that control waits for response from corresponding node. Once the response is response is received same process is repeated for all three nodes. If any node is unresponsive corresponding error is raised and sent to remote end.

Once sensor data is collected from all nodes then MQTT packet is prepared. Before sending this packet to the server through modem first GPRS connection is checked if GPRS is not connected then connection to server made and then packet is sent to server.

If any control action needs to execute on particular node then server sends the control query to gateway. Modem receives this information and sends an Unsolicited Result Code (URC) to the microcontroller over UART. This URC is analysed and corresponding action flags are set to indicate that control information to send to particular node. If any such flag is set then control query is formed and sent.

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