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Grocery Inventry Automation Using Internet of Things and BLE Network

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ABSTRACT: Goal of any innovation and development is to provide comfort and ease to human life. The rise of the term Smart Homes in resent years is due to the possibility of applying Internet of Things (IoT) for the home automation. But currently main focus of the IoT is limited towards controlling different home activities. Most of the proposed IoT based solutions is not focusing on one main part of the home, kitchen, where actually large amount of data exists and which is need to be updated day to day. Through this paper we have proposed IoT and Bluetooth Low Energy (BLE) based connected kitchen which will not only be connected to all family members of that house but also to the grocery stores, milkman, medical stores, family physician, etc. The proposed solution will provide ease of life to the families in metro cities. The proposed solutions uses the Bluetooth Low Energy (BLE) protocol for development of low cost and low power consuming nodes. The WSN is formed using these BLE nodes with the help of low power sensors, IoT, MCU with integrated BLE, Cloud Storages, Android Applications, WiFi, etc.

KEYWORDS: Internet of Things (IoT), Wireless Sensor Network (WSN), Cloud Storage, Bluetooth Low Energy (BLE), Android, Smart Homes, Connected Homes, etc.

I. INTRODUCTION

The Smart Home term coined in the recent years due to the advancement in the IoT concept. The possibilities of applying the IoT concept to the home to turn it into a smart home, making the IoT more popular in the domestic market rather than industrial market. Smart home is nothing but the home automation. Such automated homes would be connected to its user all the time through the wireless technologies like Bluetooth, ZigBee, WiFI or the big word wide web. Thus we can say that wireless communication technologies plays a key role it the smart homes. It has been observed that the current focus of the smart homes is towards controlling the home appliances remotely through the internet. Sometimes it has been used for the remote data logging like used in the smart meters. Generally speaking the IoT approach is used in smart homes to control domestic activities such as home entertainment system, houseplant and yard watering, pet feeding, changing the ambiance “scenes” for different events, lighting control, domestic robot control, different domestic security systems, etc. Thus through integration of information technology with the home environment, systems and appliances can communicate in an integrated manner which results in convenience, energy efficacy, and safety benefits. Hence broadly speaking IoT and smart home concepts is got applied to the activities in the leaving room, study room, garden and yards of the house. But the kitchen cooking activity, food habits got neglected though it is one of active and busy part of the homes. Cooking habits and food are also directly related to the health of the family. It would be not only improve the comfort but also improves the health of the family if integration of IoT to this part of the home. The developed system tracks the grocery in the house hold day to day. Depending on the stock of the grocery, it takes decisions. It informs the family members about the grocery stock on daily basis. If needed it automatically informs the grocery shop, milkman, vegetable and fruit shop. It places an order for the groceries which are ending. Through the analysis of the daily data, it can also give health tips and suggestion about food habits of that family. If the daily collected data put on to the open cloud, the retail shops can suggest the products depending on the data analysis. They can put different offers as per family habits. Thus collected data will be very much useful for the marketing and advertising activities and other big data analysis as well.

Realization is done through the components BLE WSN network, which forms the wireless sensor nodes along with connected sensor, Smart Home Central Controller, which will collect all the data for analysis and decision making, cloud storage and User mobile application, etc.

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II. System Architecture

The system is having the architecture as below which consist of Wireless node, data collection and analysis center, gateway to the cloud, cloud, etc. The data collection center and getaway to the cloud can be used for other IoT based systems also along with proposed system to form an integrated home automation system.

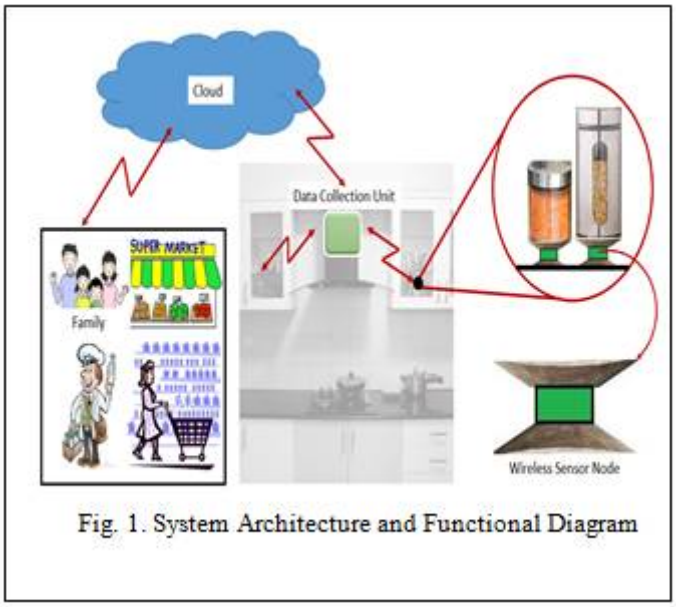

Fig. 1. System Architecture and Functional Diagram

The fig. 1 shows the architecture of overall system. Each kitchen container which contains grocery, forms a node due to the stand connected to it as shown in fig. 1. The node is having a force/weight sensor connected to it. The node periodically samples the weight of the grocery box attached to it. Once the weight falls below the set threshold value, it activates its BLE radio and updates the Data Collection Unit about it. Data Collection Unit updates the stock status and also push the status to the cloud. Thus the family and shops connected to the cloud gets notification about it.

III. Hardware Design

The very basic block diagram of the node is as shown in the fig. 2. The node consist of the BLE & MCU (QN9021) as the central unit, battery (CR2032), Force Sensitive Resistor (FSR), and BLE RF Network (Antenna). The switches and LEDs are provided for user interface purpose.

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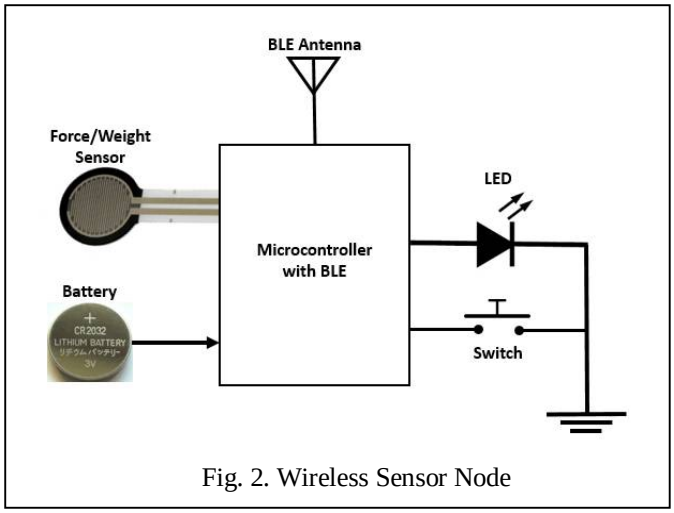

Fig. 2. Wireless Sensor Node

The FSR converts the change in weight of the grocery to change in the resistance. Which then gets converted to the voltage through the voltage divider network. The change in the voltage measured by the ACD of the MCU. Depending on the reading from the ADC and the set threshold limit, the MCU activates built in the BLE radio. Once the reading exceeds the set threshold limit, the MCU transmits the status to the Data Collection Unit through BLE. There after the software takes control of the logical flow.

As the node is wireless and need to be portable, lot of constraint on the size, power consumption, etc. The main constraint is power consumption. A power calculation for the present developed system is shown in previous TABLE.

Steps	Details	Current (mA)	Active Period (Sec)	Total Energy
1	Active Mode	4.00	60	240.00
2	Bluetooth Tx	12.00	1	12.00
3	Bluetooth Rx	12.00	0	0.00
4	IR LED	20.00	1	20.00
5	Total (for 1 Activation Instance)			272.00
6	Activation Instances (x times device activated)			5
7	Revised Total with Considering Activation Instances			1360.00
8	Sleep Mode	0.0040	86090	344.36
9	Revised Total with Considering MCU Sleep Period			1704.36
10	Average Current			0.0197
11	Cycle time(Sec)			86400
12	Battery Capacity (mAh)			180
13	Battery Life in Hours			9124.83
14	Battery Life in Days			380.20
15	Battery Life in Months			12.67
16	Battery Life in years			1.06

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IV. SOFTWARE DESIGN

The flow chart shows the program flow in the Wireless Sensor Node. For most of the time the controller remains in sleep mode to attain better battery life. Thus the MCU powers on the BLE radio only when data is needed to be uploaded. The algorithm is light weighted so that it executes at the very low clock and quickly to further save the power.

The loaded program in the nodes have capabilities of self-firmware updating, threshold value updating. All these are done through the time based polling method using the timers to avoid programing and execution overload as well as overload of buttons to activate these functions.

Software developed to interact with the cloud using standard Application Program Interface (API). The more software complexity is shifted towards the Data Collection Unit and the cloud. Thus node is running lesser complex algorithms leaving the complexity to the other components of the system. By this the updating and bug fixing of the system becomes easy and hence scope of the further improvement in the above stated system exists all the time. The main software design components are Web Browser, Cloud APIs, etc.

Design Challenges Faced

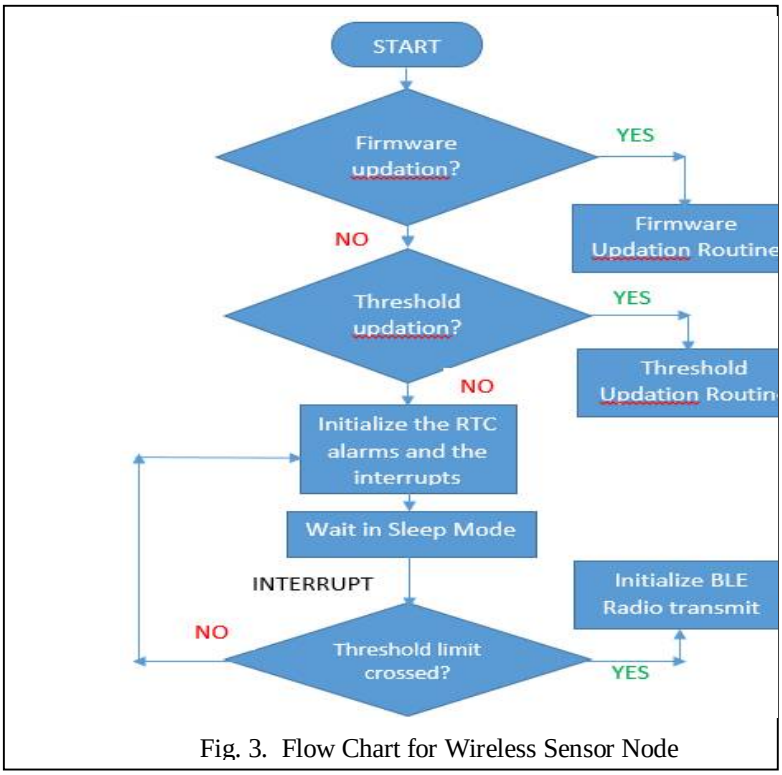

Fig. 3. Flow Chart for Wireless Sensor Node

A. Power Constraint

There was tight constraint of power consumption. To make the solution practically applicable, the battery life of the node is targeted to at least more than one year. Rechargeable batteries could not provide the solution since in that case it is not easy to recharge such hundred nodes on daily or alternate day basis. In current system battery life achieved is approx. above 4 years.

B. Size

The size of the actual system is kept as small as possible so that the provided solution would not acquire more space in the kitchen. There is only 0.1% space consume by the solution of the normal container. The size limitation also restricted the size of the battery.

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C. Protection

The node is well protected from the dust, heat, water, moisture, humidity and pressure as it is being used in the kitchen.

D. Cost

The solution provided by the above system should be economical. The main cost components is the wireless node. As there may be need of hundreds of such node to cover the kitchen, the initial investment cost should be as minimum as possible with the longer life time. The design of the system is such that it requires less electronic components and processing. Currently electronic cost of the one Container is approx. Rs 150 and cost of the Data Collection Unit is around Rs 500.

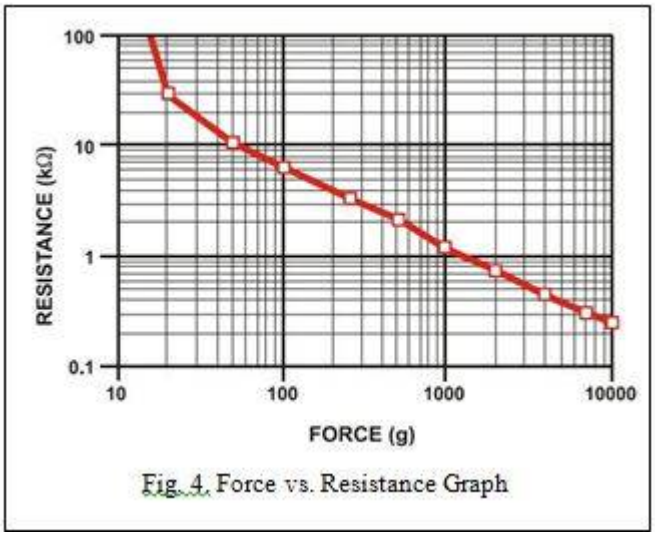

Fig. 4. Force vs. Resistance Graph

The fig 4 shows the force versus resistance graph of the FSR. It is observed that the response of the sensor is not linear. Hence piece wise linearization techniques are applied, this hampered the sensitivity of the wireless sensor node, It is also difficult to measure a minute changes in the stock. But the application does not demands that much accuracy

V. User Application

The fig 5 shows the glimpse of the current user application which can be used on the smart android phones as well as on full-fledged PC. The user application provides interface between the cloud data and the user. The user can set the alert system for the each stock separately. The color scheme can be customized. Red color shows the stock which is below 20%. Yellow color indicates stock below 60% while Green indicates stock above 60%. The user can be notified or the further any other process can be triggered depending on the value of the current reading.

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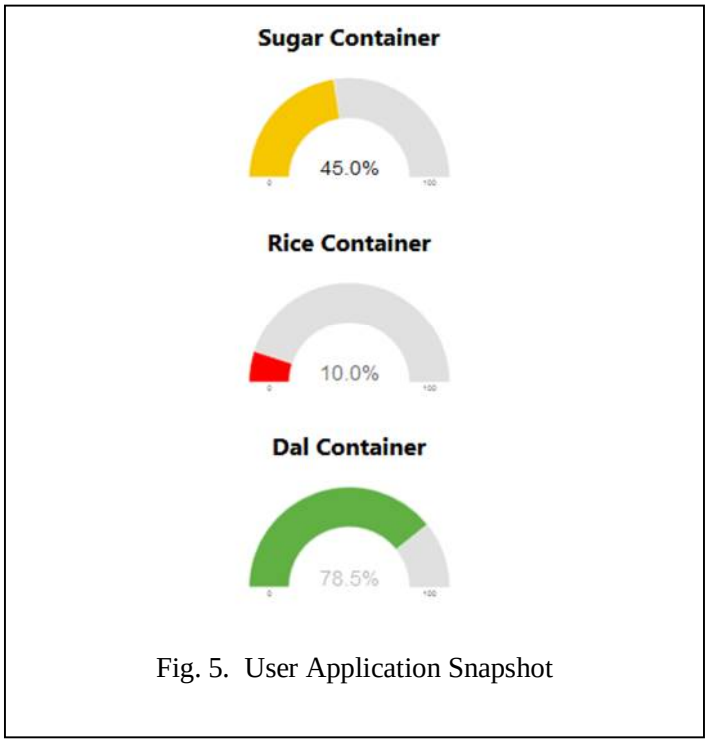

Fig. 5. User Application Snapshot

VI. Conclusion And Future work

The paper discusses how IoT and WSN together is applied to the smart kitchen in the connected homes. The implemented solution is economical, and practical and possible. Though design challenges discussed are already overcome through proper designing still there exists a scope for improvement in the stated system. The performance of the system is yet not evaluated in the long run. The practical battery life and life time of the system is yet to be evaluated. On field challenges like range of the BLE, disturbance and interference due to other devices working in the same frequency band of 2.4GHz, etc are yet to be examined. The system is tested for shorter period. The main area where further work is required is the sensor accuracy and sensitivity. Possibility of the other sensors like strain gauges, piezoelectric sensors, etc has to be evaluated. The selected sensor is needed to be cheap, less power consuming. How the stated system can be accommodated in the current IoT based smart homes is also a challenge. The system can also be implemented for industrial purpose to monitor oil levels, various raw material levels, etc for different processes. The industrial implementation need to be dealt with the security issues other than all the present design issues.

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