Internet of Things (IoT) for building Smart Home System

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***Abstract* – Internet of Things (IoT) is an emerging technology that is making our world smarter. The idea of connected world cannot be imagined without IoT. An IoT based Smart Home is one such example. In IoT enabled Smart Home environment various things such as lighting, home appliances, computers, security camera etc. all are connected to the Internet and allowing user to monitor and control things regardless of time and location constraint. This paper describes Frugal Labs IoT Platform (FLIP) for building IoT enabled Smart Home. This paper discusses functions of Smart Home and its applications and introduces FLIP architecture with implementation of Smart Home services using FLIP through a proposed system. The proposed system presented in this paper is used for monitoring and controlling Smart Home environment.**

Keywords – IoT platform architecture; smart home; machine to machine communication;

I. INTRODUCTION

A smart home also referred to as a connected home or eHome is an environment for living that has highly advanced automatic systems. A smart home appears "intelligent" because its daily activities are monitored by a computer. A smart home consists of many technologies via home networking for improving quality of living. A smart home is a place that has highly advanced automatic systems for controlling and monitoring lighting and temperature, home appliances, multi-media equipment, and security systems and many other functions. IoT [1] plays an important role in building smart home. Through IoT almost every object of our daily life in a home can be connected to the Internet. IoT allows monitoring and controlling all of these connected objects regardless of time and location [2].

II. MOTIVATION

As the consequence of digital India program, cities in India will soon be transforming into smart cities. A smart city in an environment and infrastructure which is highly depends upon Internet for communication and services. Thus IoT is a key factor for building smart cities. A smart home system, proposed in this paper, is a component of a smart city. The motivation behind this paper is to propose a smart home system that can be implemented in smart cities in India.

III. FUNCTIONS OF SMART HOME

A smart home system consists of applications built on top of IoT infrastructure. The smart home applications can have following main functions [3] -

A. Alert

The smart home system is able to sense its environment and accordingly send alerts to the user on registered device or account. The alert consists of information related to environmental data. This information may include level of different gases in the environment, temperature, humidity, light intensity etc. alert may be sent to user on regular basis at predefined time. Alert

may be sent over email, as a text message, through tweets or through any other social media.

B. Monitor

This is the most important function of smart home. A smart home is capable of monitoring its surrounding with the help of various sensors and camera feed. Monitoring is an important function as it keep track to every activity in a smart home which is the primary need on basis of which any further action can be taken or decision can be made. For example monitoring room temperature and sending alert to user to switch on air-conditioner if temperature is above threshold.

C. Control

This function of smart home allows user to control different activities. The activities may include switching on/off lights, air-conditioner, and appliances, lock/unlock doors, open/close windows and doors and many more. User can control things from same place or from remote location. This function even allows user to automate activity such as automatically switch on/off air-conditioner when room temperature high/low.

D. Intelligence

Intelligence or Home Intelligence (HI) is the most significant function of smart home and refers to intelligent behavior of the smart-home environment. This function is related to automatically making decision on occurrence of various events. HI depends upon the Artificial Intelligence (AI) mechanism built in the smart home environment. HI does not only give brain to smart home but it is also very important for security point of view in a home [4].

HI creates an integrated environment in the smart home in which the AI mechanism can identify and suitably react according to changing conditions and events. By identifying abnormal or unexpected events HI can alert user and provide an immediate automatic response if desired. Some scenarios for illustration are automatically prepare coffee as soon as user arrives, send alert to user whenever suspected activity is detected at door or inside home, automatically order stuff whenever there is a shortage in refrigerator, sending notification to electrician/plumber whenever maintenance is needed etc.

IV. SMART HOME APPLICATIONS

Although the application area of a smart home is only limited by human imagination, this paper illustrates some of them which are described below-

A. Smart Lighting

Smart lighting is used for energy saving which can be achieved by adapting lighting to the ambient conditions and by switching on/off or dimming of lights according to user needs thus reducing the unnecessary use of energy. Saving energy also helps in reducing cost. The smart lighting can be implemented with Solid State lighting (LEDs) or IP-enabled lights (Internet or wireless controlled). The smart lighting works by sensing the occupancy, temperature/humidity and LUX level in the environment.

B. Smart Appliances

Smart appliances are used for gathering status information of appliances and to easily control appliances from within the room or remotely. It is also used for scheduling tasks at predefined time and for runtime integration between appliances. Smart appliances save energy and time.

C. Intrusion Detection

Intrusion detection is used for alerting user through email and text message. The intrusion detection application can also send detailed report with images or audio/video clip to the user. The main goal of this application is to monitor suspected activity in smart home and alert user and take necessary actions for security purpose.

D. Smoke/Gas Detection

This application is used for sensing the smart home environment for healthy living and can also be used for security. This application is used for optical detection, ionization, and air sampling technique. It is capable of raising alert to near by fire station in case of fire and smoke and to user via email/SMS informing them about health risks.

Discussed above are few, but not the least, applications of a smart home environment which are useful to improve safety and quality of living. This paper describe FLIP platform for developing such application and also discuss an experiment with result using FLIP in next section.

V. FLIP ARCHITECTURE

FLIP developed by Frugal Labs Bangalore, India is an open source IoT platform aimed for developers, Hobbyists, and anyone interested to learn and work on IoT to transform their idea to "Proof of Concept". FLIP is a complete IoT platform and not just collection of devices and sensors or cloud services for building IoT infrastructure. FLIP architecture represented in Fig. 1 [5].

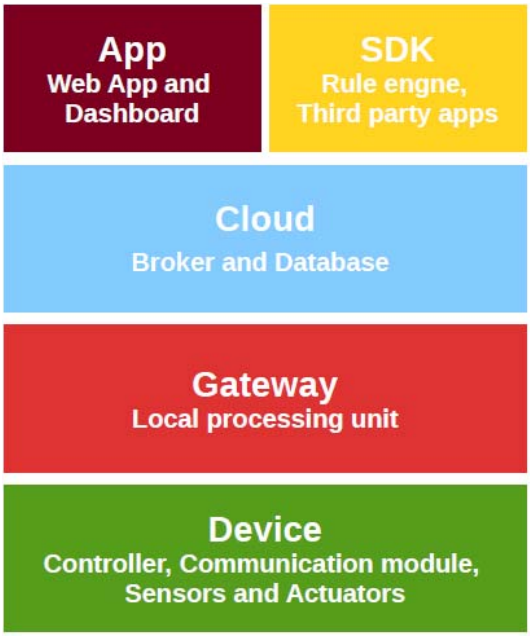

Fig. 1. FLIP Architecture.

The FLIP architecture has four distinct layers device, gateway, cloud, and app & SDK.

A. Device Layer

Device layer consists of controller, communication module, sensors and actuators. In this layer FLIP base board is used as controller. FLIP base board is based on Arduino Nano [6]. For smart home application this layer also uses FLIP smart home shield. The smart home shield stacked over base board to extend functionality of the base board. Smart home shield has temperature & humidity, light intensity (LDR) sensors attached to it and also allows to connect other sensors such as PIR and various gas and air quality sensors, sound sensors and many more. Smart home shield also has Alternating current (AC) relay which can be used to control anything up to 7 amps of current and 250 volts AC current. It enables to connect home appliances, home lighting etc. The FLIP smart home shield is displayed in Fig. 2 [5].

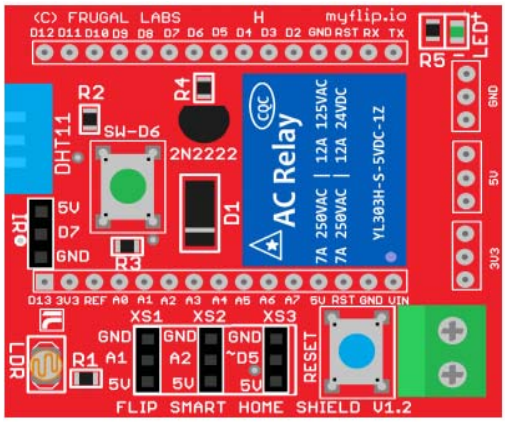

Fig. 2. FLIP Smart Home Shield.

For connectivity at device layer FLIP board uses Wi-Fi/Bluetooth module. Both modules can be connected to FLIP base board directly via 6-pin interface. Wi-Fi module, shown in Fig. 3 [5], directly connect FLIP device to the Internet and Bluetooth module, shown in Fig. 4 [5], connects FLIP device to Internet via gateway layer in the architecture.

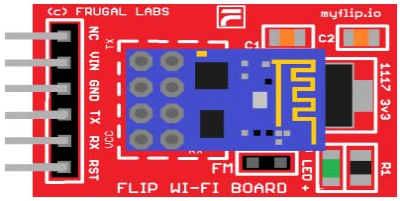

Fig. 3. FLIP WiFi Module.

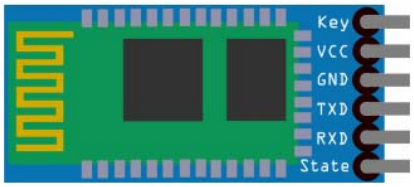

Fig. 4. FLIP Bluetooth Module.

B. Gateway Layer

Gateway layer consists of local processing unit which is based on Linux operating system. FLIP architecture uses Raspberry PI 3 [7] as gateway device. Gateway device has Bluetooth connectivity which allows other devices to

connect to it. In the architecture all the devices are connected to gateway and gateway is connected to the Internet. Gateway is connected to Internet through Ethernet or Wi-Fi.

C. Cloud Layer

Cloud layer consists of broker and the database. Broker connects to all the devices and database stores the data coming from the devices. The cloud layer has three main structures MQTT broker named Mosquito [8], Mongo DB [9] database and Node.js [10] for backend processing.

D. App & SDK Layer

The top layer is App & SDK layer. The app consists of web app and dashboard and is used for data visualization using widgets and graphs. Using dashboard devices can be monitored and controlled. SDK has rule engine based on python [11]. The Python SDK has two scenarios one is to define logic to your device i.e. if temperature is this much then switch on air-conditioner, and second it can connect to social media or third party apps.

VI. PROPOSED SYSTEM

The proposed system discussed in this study is based on FLIP. The proposed system has four main application modules smart lighting, smart appliances, intrusion detection, and smoke/gas detection as discussed in the previous section. Fig. 5 [5] displays basic device setup diagram for smart home lighting control including temperature, humidity, light intensity and motion detection sensing capability.

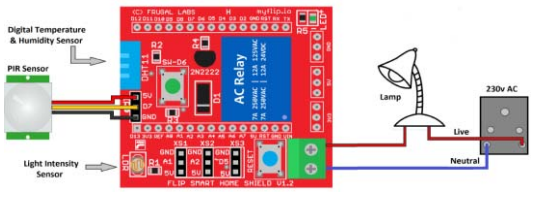

Fig. 5. Smart Home Device Setup.

The proposed smart home network structure is displayed in Fig. 6.

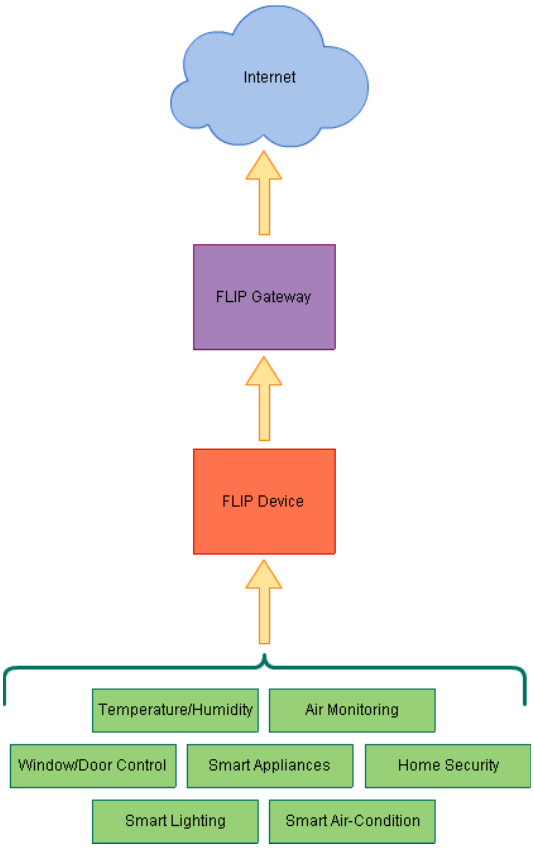

Fig. 6. Smart Home Network.

In the proposed smart home system FLIP device is connected to sensors, lights, air-conditioner, camera, windows and door system, and various appliances. The flip device is connected to the Internet via gateway. Gateway in the proposed smart home network plays an important role as it add an extra security layer to the smart home network thus making the proposed system more secure. The proposed smart home system is capable of performing various functions such as monitoring environment for air quality and security purpose, controlling home appliances, locks, doors and windows from remote location, generating alerts and notifications at preset conditions, adjusting room lighting and temperature by sensing light intensity and temperature/humidity level in the room and thus automatically controlling lighting system and air-conditioner. Following C language firmware code, uploaded on one of the FLIP device, publishes temperature and humidity and light intensity data and also allows turning

light on/off remotely. The following code segment from proposed smart home system sends temperature, humidity, and light intensity data to server and also allows user to control electric switch remotely.

```
#include <FlipSmartHome.h>
#include <FlipMqtt.h>

FlipSmartHome fsh;
FlipMqtt m;

char* temp_topic ="Home/temp";
char* hum_topic ="Home/hum";
char* ldr_topic =" Home/light";
char* switch_topic="Home/switch";
char* ssid="ssid";
char* pwd="password";
int temp, hum, ldr;
char* s=NULL;

void setup()
{
 m.mqttSub(switch_topic);
 m.mqttBegin(ssid,pwd);
 fsh.relayOff();
}

void loop()
{
 s=m.GetSubValue(switch_topic);
 if (strcmp(s,"1")==0){
   fsh.relayOn();}
 else{
   fsh.relayOff();}

 temp = fsh.readTempC();
 m.mqttPub(temp_topic,temp);

 hum = fsh.readHum();
 m.mqttPub(hum_topic,hum);

 ldr = fsh.readLdr();
 m.mqttPub(ldr_topic,ldr);
}
```

The proposed system visualize data using widgets and graphs in web app and also provides widgets to set alert conditions and controlling devices such as opening/closing doors and windows, turning on/off lights and other equipments. System also allows users to download all tracking information in excel format and add new logic to the system using python script whenever required thus making system flexible. It is also possible to add new devices to the system. Fig. 7 [12] displays user interface of a web app.

Fig. 7. Web App Interface.

User can also define the medium for receiving alerts and notifications. The different mediums can be email, text message, and social media. User can choose any one or all. Following python script sends e-mail alert if light intensity in higher.

```
import FlipUtilities as Flip
import FlipMQTT as mq
import time
import getpass

mqtt = mq.FlipMQTT()
mqtt.sub_topic("Home/light")

mqtt.infy()

service = 'gmail'
Flip.selectService(service)
username = “username”
password = “password”
to = "to-email-address"
frm = "from-email-address"

Flip.emailCredentials(username, password)
print "Logged in successfully!"

received_data = []
check_timestamp = '0'
```

```
while True:
   received_data = mqtt.sub_value("Home/light")
   if received_data != None and
received_data[1]!= check_timestamp:
      print received_data
      if (received_data[0] >= "500") :
         check_timestamp = received_data[1]
         subject = "Sensor Values"
         message = "Light Intensity is "+
received_data[0]+"
Time:"+received_data[1]+""+" Turning OFF
Room Light."+""
         Flip.sendMessage(to, frm, subject,
message)
         print"message sent!"
   time.sleep(5)
Flip.closeEmail()
```

Currently the proposed system performs functions as described in this section but it is not limited. Any new functionality to the system can be easily added thus making system extensible.

VII. RESULT

The proposed system is very helpful in monitoring and controlling smart home environment. Using this system air quality can be continuously monitored in home and alerts can be sent to user about health risks if any. Proposed system also improves security. User can monitor every activity in home and can control windows and doors. This system also ensures better utilization of energy and resources through smart lighting, smart appliances and smart air-conditioning system. Fig. 8 displays email notification received at user's registered email account as the higher light intensity detected in the room and as a result room lights were automatically turned off by the system.

Fig. 8. E-mail Alert.

The proposed system was tested and performance was as expected.

VIII. FUTURE SCOPE

The proposed IoT based smart home system can be implemented in future smart cities in India. Currently the proposed system performs various functions as described in above sections. In future, the proposed system can be extended to perform other functions such as water and waste management.

IX. CONCLUSION

With the rapid development of Internet and communication technologies today's homes also have strong computation and communication abilities. An IoT based smart home is emerging as an important part of the smart and intelligent cities which are being proposed and developed around the world. The purpose of a smart home is to improve living standard, security and safety as well as save energy and resources. The smart home plays an important role in development of society. The aim of this paper is to propose such system based on FLIP. The system presented in this paper is highly flexible and extensible for user needs with security concerns. The proposed system can be implemented as per user requirement.

REFERENCES

[1] Jayavardhana Gubbi, Rajkumar Buyya, Slaven Marusic, Marimuthu Palaniswami, "Internet of Things (IoT): A vision, architectural elements, and future directions", Future Generation Computer Systems (Elsevier), 2013, pp. 1645-1660.

[2] Boban Davidovic, Aleksandra Labus, "A SMART HOME SYSTEM BASED ON SENSOR TECHNOLOGY", Electronics and Energetics Vol. 29, No 3, September 2016, pp. 451 – 460.

[3] Jayashri Bangali, Arvind Shaligram, "Energy efficient Smart home based on Wireless Sensor Network using LabVIEW", IJER, Vol. 2, Issue 12, 2013, pp. 409-413.

[4] David Bregman, "Smart Home Intelligence - The eHome that Learns", International Journal of Smart Home, Vol. 4, No. 4, October, 2010, pp. 35-46.

[5] Frugal Labs Tech Solutions Pvt Ltd, www.frugal-labs.com.

[6] Arduino Nano Board, http://www.arduino.cc.

[7] Raspberry Pi 3, http://www.raspberrypi.org.

[8] MQTT a machine-to-machine (M2M)/"Internet of Things" connectivity protocol, http://mqtt.org/.