Mobile app based Smart Office framework with support for data analytics on cloud

S. Dyaneshwar, K. Monica, G. Jaiyashri , K. Muthumeenakshi,

Dept of Electronics and Communication, SSN College of Engineering, Chennai, India

Abstract- Automation is one of the growing fields in today's world. Human desire to make life more comfortable is the main driving force behind such automation technologies. It leverages the benefits of available tools and technologies such as device controllers, web services, mobile platforms, together with well known concepts of machine learning. Beside the decrease of energy consumption, this solution can manage and monitor devices present in a person's office cabin, if available, and therefore its application results in more granular control an individual's workspace. Making the office cabins more smart are integral part of enabling employee friendly office setups.

Keywords- Office automation, Data analytics, IoT, Raspberry Pi

I. INTRODUCTION

Office automation is a term which refers to the automation of various office activities. Home automation may include centralized control of lighting, heating, ventilation and air conditioning, appliances, and other systems, to provide improved convenience, comfort, energy efficiency and security. Automation for the elderly and disabled can provide increased quality of life for persons who might otherwise require caregivers or institutional care . Such system integrates various electrical devices in a office. The techniques employed in office automation include those in building automation as well as the control of domestic activities, such as office computer systems, houseplant and yard watering, pet feeding, changing the ambiance "scenes" for different events (such as dinners or parties), and the use of domestic robots. Devices may be connected through a computer network to allow control by a personal computer, and may allow remote access from the Internet. Typically ,a new office building is outfitted for automation during construction, due to the accessibility of the walls, outlets, and storage rooms, and the ability to make design changes specifically to accommodate certain technologies[7]. Wireless systems are commonly installed when outfitting a pre-existing buildings, as they reduce wiring changes. Wifi, zigbee, Bluetooth are commonly used as the enabling platforms[5]. These communicate through the existing power wiring, radio, or infrared signals with a central controller. Network sockets may be installed in every room like AC power receptacles. The goal of this paper is to describe a system designed to help automate the devices in a employee's cabin and optimize their electricity consumption. The key component of the system is an intelligent controller cable of responding to user commands over the internet and controlling the devices based on preset conditions. A smart living, workplace makes life easy and comfortable and increases their ability to stay connected through the use of technological solutions like mobile apps using bluetooth or Wifi[2][3].

II. PROBLEM DESCRIPTION

According to the Ministry of Statistics and Programme implementation, commercial establishments in India consumed 8.59% of overall energy consumption during 2017 [11]. With rapid urbanization and growing number of startups the consumption is bound to increase. Project described in this paper is directly motivated by this evidence. In addition to the this utility The objectives of the proposed solution could be divided into following general categories:

- Reduce overall electrical energy wastage.
- Enable remote monitoring of employee's cabin through a mobile app.

- Manage devices present in a office cabin using mobile App.
- Provide a platform for aggregating sensor data for future analysis.

III.PROPOSED SOLUTION

Figure I shows the proposed system. To achieve the objectives listed in the previous section, the proposed solution uses tools and technologies that are already available, or will be available in the near future, and uses them in a new way. Smart phones, office automation devices, home computers and case-based reasoning have been known for a while now and data analytics, machine learning happens to be most promising technologies of the future. Combining these the goals listed out in previous section can be achieved. The system consists of a master controller, slave controller ,server application and client devices. The server application can be hosted at any kind of personal computer. Raspberry pi is used in our work to implement server application while the client could be implemented both as an application for smart phone and tablet devices, and as a standard web application, accessible from various browsers

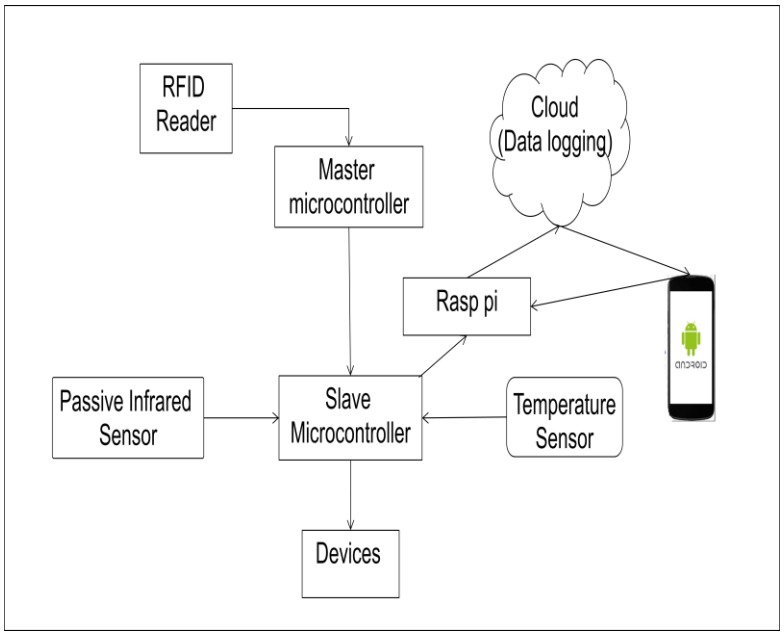

FIGURE I. BLOCK DIAGRAM

The proposed solution can be easily integrated into existing office setups as most of them have a RFID enabled Identification cards issued to their employees. Smart office devices can be controlled via a control panel by the user on a mobile phone or an android tablet; these devices will be connected to the internet or to the local network available. Arduino microcontroller will be using either Wifi interface or Ethernet to connect to local network. Objects or devices and sensors in the home will be connected to Arduino[8]. The arduino sends and receives data from the internet through Raspberry Pi. Firewall settings can be configured on both the router and on Raspberry pi which will be additional advantage of having 2 level securities in this design. If the smart office controller is connected to local office network then internet connectivity is not required, internet connectivity is only required when the user moves out of office and needs to control devices remotely[10].

IV. SYSTEM ARCHITECTURE

A. Hardware components

The hardware components in this smart office are divided into four parts viz. Raspberry Pi, Arduino Uno, Sensor modules, Output devices like LED. Raspberry pi acts as the wireless gateway between the Arduino and Network. Raspberry Pi is a Linux based embedded system. The Raspberry Pi 3 Model B as shown in fig II is equipped with onboard Wifi card, Ethernet and Memory card slot. It is based on Broadcom BCM2837 with a 1.2Ghz 64-Bit aud-core ARM Cortex-A53 processor.

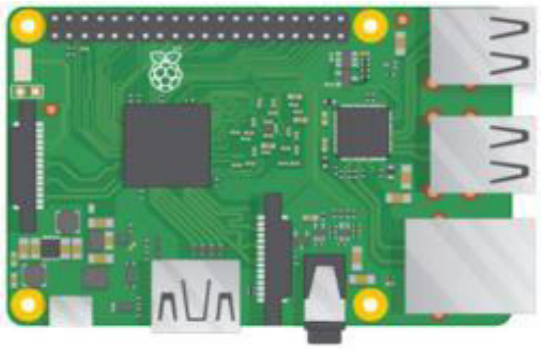

FIGURE II RASPERRY PI 3 MODEL B

The Pi can easily be integrated with a Arduino Uno using serial communication port. It runs on a Linux operating system and has 1Gb RAM and wide variety of expansion ports. The Pi has HDMI, USB, MicroSD and VGA ports. There are 17 GPIO pins for interfacing with sensors and modules. The Pi runs on 5V microusb external power. The interfacing software is written using python. User input are obtained using keyboard and mouse which connect via USB [4].Arduino UNO shown in fig III is a general purpose microcontroller often used in automation projects for controlling various devices. Here both the master and slave micro controllers are Arduino UNO. It has the advantage of low cost, easily programmable using dedicated IDE, low power requirements and support for embedded C.

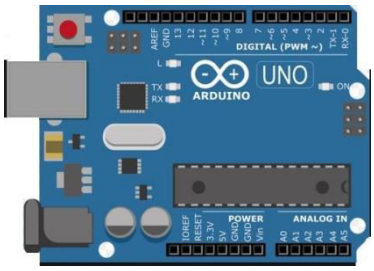

FIGURE III. ARDUINO UNO

Relays are used to switch the high power devices where these relays are controlled through the digital pins of Arduino. A 5v relay module must be used for Arduino to work. A relay can be called as an electromagnetic switch; fig IV shows a 4 channel 5v relay module for Arduino, it has onboard optocoupler which divides the whole circuit and ensures the microcontroller safety.

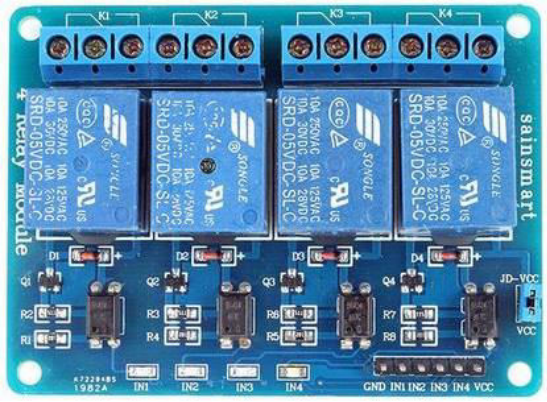

FIGURE IV.RELAY MODULE(4 CHANNEL)

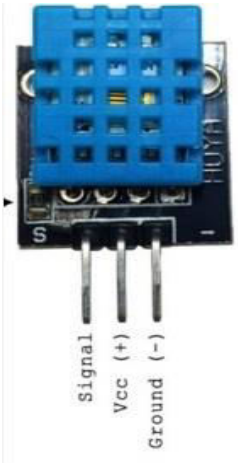

FIGURE V.DHT 11

DHT 11 temperature sensor is used to detect the temperature of the room; it has capability to measure the temperature accurately and gives the output temperature in the form of voltage proportional to Celsius. DHT11 accepts input voltage between 4volts to 30 volts as Vcc but commonly used are 5v and 12v.

RFID systems are widely used to record attendance in many corporate companies. It consist of RFID reader and cards as seen in fig VI(a). RFID systems can be classified by the type of tag and reader. A Passive Reader Active Tag (PRAT) system has a passive reader which only receives radio signals from active tags (battery operated, transmit only). An Active Reader Passive Tag (ARPT) system has an active reader, which transmits interrogator signals and also receives authentication replies from passive tags. An ARAT system uses active tags awoken with an interrogator signal from the active reader. The communication between card and reader takes place over 13.56Mhz ISM band which supports a 10-20cm separation distance. Each RFID card is unique to each employee and coveys information about the employee. The RFID reader is capable of reading the information stored on the card.

(a)RFID card and reader (b) PIR sensor

FIGURE VI.

A passive infrared sensor (PIR) is an electronic sensor that measures infrared (IR) light radiating from objects in its field of view. They are most often used in PIR-based motion detectors. All objects with a temperature above absolute zero emit heat energy in the form of radiation. Usually this radiation is at infrared wavelengths. The PIR sensor picks up this radiation.

An individual PIR sensor detects changes in the amount of infrared radiation falling upon it, which varies depending on the temperature and surface characteristics of the objects in front of the sensor. When an object, such as a human, passes in front of the background, such as a wall, the temperature at that point in the sensor's field of view will rise from room temperature to body temperature, and then back again. The sensor converts

the resulting change in the incoming infrared radiation into a change in

B. Software components

1) Arduino Integrated Development Environment

It is open source software basically written in java makes the programmer easy to write the code in embedded c language and upload the code to board in one click. Cineodes written in this software are called sketches. It has a text area to write the sketches, menu bar, message area, and a tool bar with button for common functions.

2) Python IDE

It is used on the Raspberry Pi. Python is an interpreted high-level user friendly programming language for general-purpose programming. The server application and the interfacing software for Arduino with Raspberry pi is written in python.

3) Android studio

It is the official IDE for developing apps for Google Android operating system .The mobile application was developed using Android Studio. Android Studio supports Python, Kotlin and Android Studio 3.0 supports Java 7 language features. The apps can developed on a Android studio that comes prebuilt along with the emulator. The user can choose the version of android for testing the developed app. The emulator has all the functionalities of a normal android phone.

V. SYSTEM IMPLEMENTATION

Figure I clearly shows the overall architecture of the proposed system. The microcontrollers (Master & Slave) mentioned in the block diagram are both Arduino. The master is supposed to be a central hub, common for all the cabins and slave is placed one in each cabin. Each cabin is also equipped with a Raspberry Pi that can handle the Mobile app support and interfacing of the devices to the network.

RFID BASED DEVICES CONTROL

The RFID reader is connected to the Master microcontroller which will act as a central controlling node for the entire office. On detection of a valid RFID card a corresponding signal is sent to the microcontroller attached to the particular employee's cabin. On reception of the signal the slave in-turn turns ON the devices present in the cabin. The opposite process happens when a person checks out of the office. This mechanism ensures no appliances are left in a turned ON condition

Most offices are made of numerous such cabins so the power saved is appreciable. Fig VII shows the action flow.

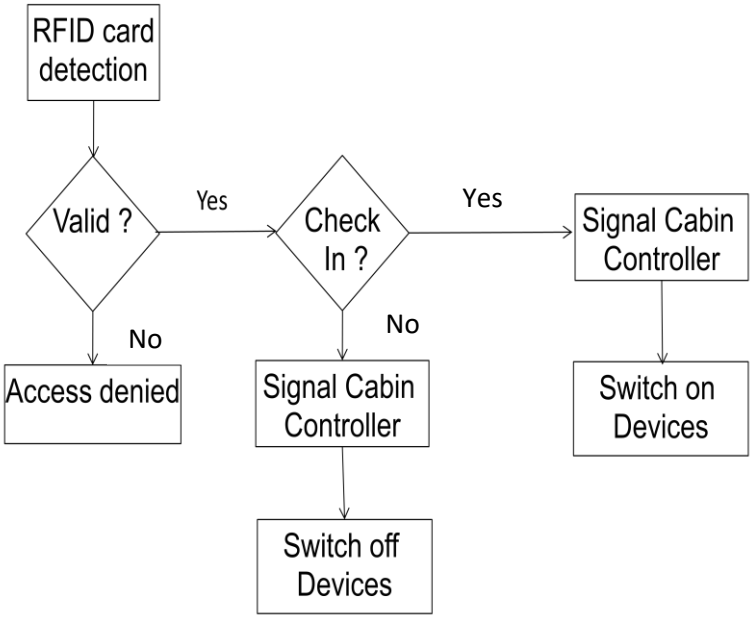

FIGURE VII. FLOW DIAGRAM

MOBILE APPLICATION FOR CONTROLLING DEVICES

Android devices have become a common thing is today's world. Such devices enable a person to stay connected to internet and perform various actions using apps. Automation projects usually always have a manual override control which is added for convenience and safety purposes. In our work we have developed a android mobile application to control the devices over wireless network. A server application to handle the request from the app is run on Raspberry Pi. A raspberry Pi is placed in each cabin and powered through 5V Ac supply[4]. Fig VIII shows the overall system design.

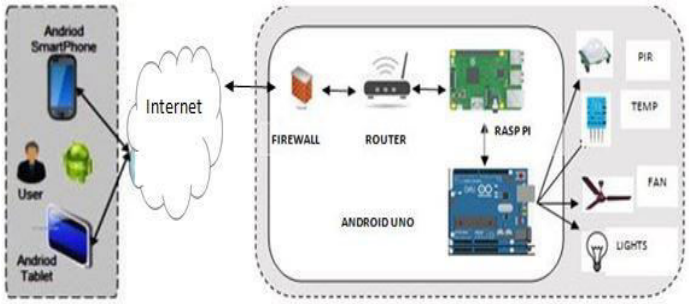

FIGURE VIII

As shown in fig VIII, the devices and mobile app should be on the same local network thereby ensuring remote users don't leave the devices turned ON after controlling them over the internet. The mobile app was developed using Android studio. The mobile app is configured in such a way that it sends the user commands to the unique control hub attached to employee's respective cabin. Both turning ON and OFF of devices are supported in a mobile app. In addition to the device control the sensors placed in a cabin can also be monitored using the mobile App

In addition to the basic device controls the app can also help in monitoring the cabin using sensors placed in the cabin. Temperature, Humidity & Motion sensors are used in our work to act as a example and other sensors can also be incorporated based on user preferences. Fig IX shows the screenshot of menu screen and temperature sensor reading displayed on the mobile app. Fig X shows the prototype developed.

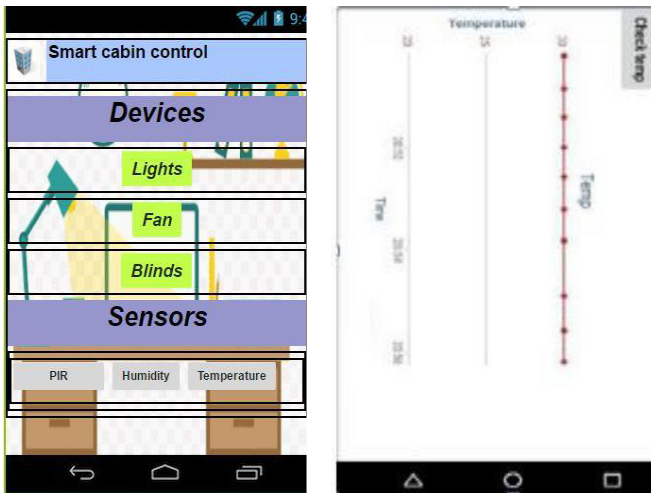

FIGURE IX.MOBILE APP SCREENSHOT

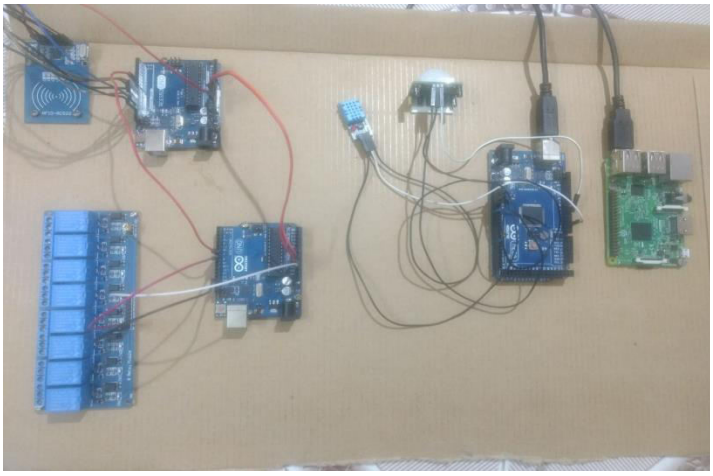

FIGURE X.PROTOTYPE

DATA AGGREGATION ON THE CLOUD

The data collected from the employee's cabin should be stored in case it needs to be processed further to gain useful insights about the working conditions. Standard data aggregation methods involve storing data on a local drive on the network or a MicroSD card. Remote access to this data is difficult as it requires physical access to these devices to obtained the stored data. The raspberry pi sends the sensor data to cloud[4]. Cloud storage is the best solution to enable access to this data from anywhere around the globe. Things speak cloud solution has been chosen to store the data in our work. It supports simultaneous aggregation of data from upto 8 sensors. In our work we are storing three sensor values viz. temperature, humidity, Motion detection sensor. The data can also be downloaded in excel format for offline operations.

CONCLUSION & FUTURE WORK

Scope for data analytics

Data analytics is the science of analyzing data to gain useful insights that might not seem very apparent on the surface. The insights gained from such random collection of huge data can enable us to develop more useful applications for the future. The sensors placed in the employee's cabin log the values which are sent to a cloud storage. Data analytics and Machine learning algorithms can be implemented on the cloud to learn, predict and send warnings about unfavorable ambient conditions inside the cabin. In addition this system can be modified to send control signals to the Raspberry Pi and control the devices through Arduino uno (eg. Automatic selection of air conditioner temperature based on previous data)

A virtual assistant

Most companies employ assistants for high profile positions in their organizations to aid in handling vast amount of responsibilities, deadlines, duties. Only handful of people are given such a luxury in any organizations even though the work burden is relatively uniform across the employee ranks. Thus a virtual assistant can go a long way in easing the work burden. Many virtual assistants like Google assistant, Alexa(Amazon), Siri (Apple) are available in the market but they are confined primarily to only those activities that can be achieved through a phone and internet. In contrast building a virtual assistant as part of the framework suggested in this work will add a new

dimension enabling devices control of devices based on the voice of employees, notifying them about meetings, emergencies and intruder alerts. As a example we created a virtual bot which senses intruders using the PIR sensor and sends out a tweet to the corresponding employee(Mr.ABC) notifying him about a possible intruder situation[1]. The system sends out this warning if the employee has already checked out of office. The RFID card logs aid in checking the status of employee presence. The cloud is provided with access to the RFID reader. Figure shows a the virtual bot sending out a warning tweet. The twitter handler of the bot is @office_monitor. Fig XI shows the intruder alert created by the bot.

A robust office automation system has been proposed in this paper with support for data aggregation and analysis on the cloud. The mobile app developed aids in real time monitoring and control of appliances present in a employee's cabin. With growing interest in data analytics and machine learning the enormous amount of data collected using this framework can help in creating a more employee friendly cabin which results in enhanced employee satisfaction thereby helps in increasing workforce efficiency. Also such a system would provide more granular information about the employees and can act as a foundation for developing more employee friendly company policies.

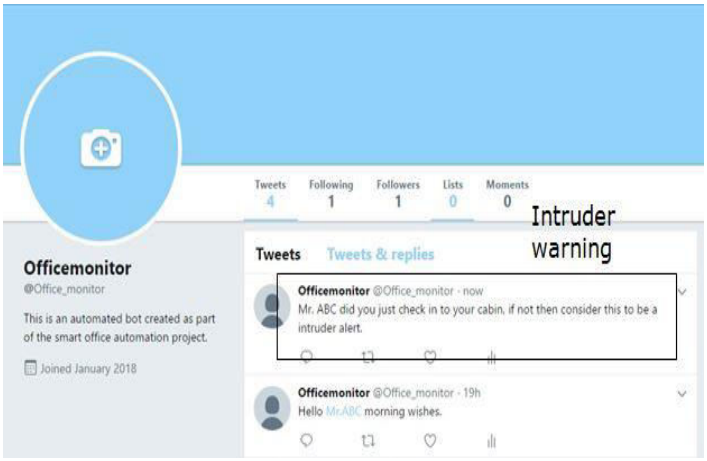

FIGURE XI .WARNING MESSAGE

REFERRENCES

[1] Siebert C; Leng M; Razul S G; Samson See C ; Wang G, "Human Motion Detection and Classification Using Ambient WiFi Signals", *Sensor Signal Processing for Defence Conference (SSPD)*, 2017

[2] Piyare, Rajeev, and Tazil M. "Bluetooth based home automation system using cell phone." *Consumer Electronics (ISCE), 2011 IEEE 15th International Symposium on*. IEEE, 2011

[3] Gill, Khusvinder, et al. "A zigbee-based home automation system." *IEEE Transactions on consumer Electronics* 55.2 (2009).

[4] Jain, Sarthak, Vaibhav A, and Goyal L. "Raspberry Pi based interactive home automation system through E-mail." *Optimization, Reliabilty, and Information Technology (ICROIT), International Conference on*. IEEE, 2017.

[5] Gomez, Carles and Paradells J. "Wireless home automation networks: A survey of architectures and technologies." *IEEE Communications Magazine* ,48.6 (2010)

[6] Kharat .P and Kharat.J "Wireless Intrusion Detection System Using Wireless Sensor Network: A Conceptual Framework." *International Journal of Electronics and Electrical Engineering* 2.2, 2014.

[7] Alheraish, A. "Design and implementation of home automation system." *IEEE Transactions on Consumer Electronics* 50.4 (2004): 1087-1092

[8] Li, Hang. "A novel design for a comprehensive smart automation system for the office environment." *Emerging Technology and Factory Automation (ETFA), 2014 IEEE*.

[9] Brush, A. J., Lee, B., Mahajan, R., Agarwal, S., Saroiu, S., & Dixon, C. (2011, May). Home automation in the wild: challenges and opportunities. In *proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 2115-2124). ACM.

[10] Uhlig, R. P., Farber, D. J., & Bair, J. H. (2014). *The office of the future: Communication and computers* (Vol. 1). Elsevier.

[11] Energy statistics (2017), Central statistics office. Ministry of Statistics and Programme implementation Government of India, New Delhi

[12] Android studio official website: https://developer.android.com/studio/index.html