International Journal of Innovative Research in Science and Engineering
Volume 10, Issue 03, 2024
www.ijirse.com
ISSN: 2454-9665

SmartNest-An Intelligent Home Ecosystem

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Abstract

This paper presents the development of a low cost smart home-automated system using Android application, which is communicating with MQTT broker for automatic control functionalities. The proposed system assists and supports people with special needs of elderly and physical impairments to increase their independence and to achieve a good quality of life. The proposed system will enable users to control remotely home appliances using an Android smartphone and a control circuit. The control unit consists of a Phidget Interface Kit, which processes the users' commands andcontrols the connected actuators such as a servo motor. By controlling the connected actuators, the proposed system can control the home appliances by using a user-friendly GUI Android mobile application. The proposed system is tested on controlling a servo motor through the developed android application, which can be used for controlling the door lock to open/close the house doors.

I. INTRODUCTION

The aim of this project is development of a low cost IoT-based smart home automation system using an Android application and Phidget controller to monitor and control home devices such as smart appliances such as lights, TV, air conditioners and much more. The MQTT protocol with MQTT broker enables the Android application to communicate with the Phidget controller to control the smart appliances. The proposed application can be used to help the special needs of the elderly and people with disabilities to monitor and control house devices such as switch on/off the lights and much more The development of IoT-based home automation for control and monitoring is getting more attentions in the r recent time. Different hardware controllers have been used for control and monitoring smart home devices such as PIC Microcontroller, Raspberry Pi and Arduino. Different wireless technologies have been used to enable the smart device's connectivity such as ZigBee, Bluetooth, and Wi-Fi for sharing information and communicating over the Internet. A typical home automation system allows one to control house hold appliances from a centralized control unit. These appliances include lights, fans, air conditioners, television sets, security cameras, electronic doors, computer systems, audio/visual equipment, etc. These appliances usually have to be specially designed to be compatible with each other and with the control unit for most commercially available home automation systems. The project "Implementation of a Low-Cost Home Automation System", demonstrates a system that can be integrated into a building's electrical system and allows one to wirelessly control lights, fans, and turn on or off any appliance that is plugged into a wall outlet. The system

ISSN: 2454-9665

can be controlled from a laptop acts as the server. Thus, the installation cost and hardware cost are kept to a minimum as most users already own the requisite hardware such as a mobile phone and desktop PC. A wire is used to provide connectivity between the server and the controller. The power supply for each appliance is wired through an electromechanical relay. A number of relays are used depending on the number of appliances to be used. All the relays are controlled by a microcontroller. The microcontroller is connected to the server via a USB interface. This makes it plug-and-play and compatible with virtually any PC. The system can be configured with time-based profiles. For example, one could have it automatically turn on the lights at 6:00 in the evening. At 10:00P.M. it could automatically turn off the main lights and turn on a night lamp. It could then turn off the night lamp the next morning. The server can also connect from the internet to receive various data

The smart home is a technology, which is used to monitor,control and automate home appliances in a way of makinghome smart. Smart home automation with the help of Internet connection is a very promising area in the IoT. It provides simplicity, convenience, comfort and security while increasing efficiency. Mobile applications or Web applications with additional equipment such as controllers can be used to monitor sensors data and control smart appliances such as lights, door locks, TV, air conditioners and much more. This application domain becomes an interestingarea for future research because of its benefits providedespecially for helping and supporting the special needs of elderly people and people with disabilities.

A. Motivation

In the last decade, smartphone owners have increased dramatically as smartphones have become all-purpose portable device and dominating many people's daily life.IoT-based home automation applications are rapidly increasing in popularity in the last few years with the rapid increase in the number of internet users and with increasing the ubiquity of IoT home devices.The integration of mobile applications with IoT-based automated systems has created a new dimension to the worldof information and communication technologies.

This paper presents a low cost IoT-based smart home automation system using an Android application and Phidgetcontroller to monitor and control home devices such as the door lock. The MQTT protocol with MQTT broker enables the Android application to communicate with the Phidget controller to control the connected servo motor which in turnused to open/close the door's lock. The proposed applicationcan be used to help the special needs of the elderly and people with disabilities to monitor and control house devices such asopen/close doors and switch on/off the lights.

B. Related Works and Contribution

The development of IoT-based home automation for control and monitoring is getting more attentions in the recent time. Different hardware controllers have been used for control and monitoring smart home devices such as PIC Microcontroller, Raspberry Pi and Arduino. Different wireless technologies have been used to enable the smart device's connectivity such as ZigBee, Bluetooth, and Wi-Fi for sharing information and communicating over the Internet.Nowadays, smart home automation systems have been developed based on mobile technologies and applications for control and monitoring home environment..

It developed a cost-effective and flexible Android application based smart home automation security system using the Internet of Things. Yun Arduino microcontroller is used for monitoring and controlling the home environment.

ISSN: 2454-9665

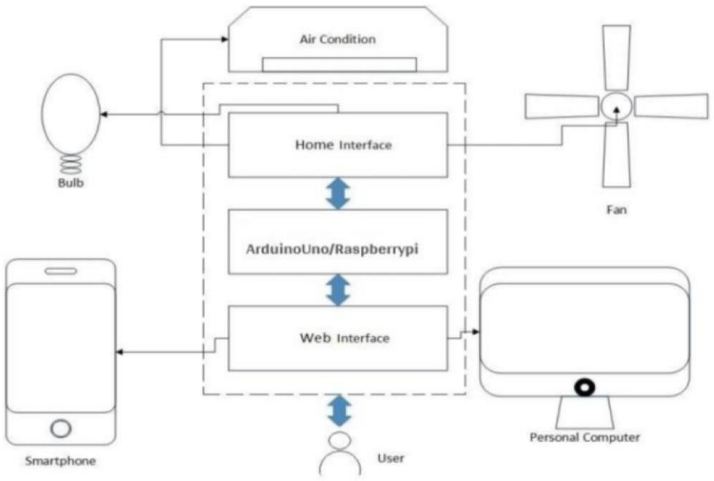
The android application acts as a platform for controlling and monitoring the home environment. It pushes messages and pulls data to/from the cloud using a lightweight messaging protocol MQTT. It developed an embedded system based IoT for controlling home and office appliances (SHOA) using android based web apps and Wi-Fi technology. Arduino Board with Wi-Fi Module ESP8266 is used to monitor and control multiple appliances. RESTful protocol over HTTP is used for ensuring packet transmission and receiver between the IoT gateway and the cloud database. In, a CoAP– based IoT architecture is proposed using a Raspberry Pi. Things-Board IoT platform is used to monitor and visualize sensors data. CoAP protocol is used to send the sensors data formatted to the Things Board cloud endpoint at regular intervals. Kumar in proposed an android-based smart home app using the RESTful protocol to communicate with the micro web-server via the Internet. The server applicationsoftware and the arduino microcontroller are used to monitorand control home devices. Ramlee et al. designed aBluetooth based Home Automation System (HAS) that controls home electrical appliances. PIC Microcontroller,PIC18F2550 is used to connect to Window and Android applications through the Bluetooth to control home appliances.

The paper proposes a low-cost smart home automation system, which uses a cost-effective controller Phidget Module compared to Raspberry Pi, Arduino and PIC Microcontroller as used in the above related works. MQTT protocol is used to communicate among mobile application and home devices. MQTT is a lightweight protocol comparedto HTTP, which is suitable for IoT constrained networks.

II. DESIGNED SMART HOME AUTOMATION SYSTEM

A System Architecture – As we can see in above figure the user can interact with the home electric devices such as fan, bulb, air conditioner etc. with mobile and even personal computer.

The user publishes the message/request „On‟ of the „Room1/Light1‟ to the broker for on the bulb. The broker distributed this message to all client subscribed to the same topic which is a Arduino/raspberry pi which controls the home interface like switch etc.



III. DISCUSS

It gives an overview of the status of smart home technologies by discussing the main relevant features and pointing

ISSN: 2454-9665

out the strengths and weakness of each technology and product. It is a guide for users, who need to choose the technology that best suits their needs. The diverse directionality and complexity of the existing communication devices represent a challenge. The growing trend is the development of bidirectional communication using a Home Automation Network (HAN) to monitor and control home appliances.de facto realizing a demand response (DR) system. According to a report published by the American Council for an Energy, Efficient Economy, some of the systems from among the new feedback initiatives that make energy resources visible to residential users achieve the maximum feedback-related savings. If all systems are to do this, they will require a combination of useful technologies with well-designed programs that successfully inform, engage and motivate the users via the following determining factors, Data collection the technology allows the collection of all relevant data and provides access to them, Data processing: the technology allows the processing and analyzing of relevant data and can combine them, Data representation: the technology allows the relevant data to be made accessible to the users, Control and interaction capabilities: the technology enables users to access the status and monitor the functions of related technologies (bidirectional communication and interaction). These factors need to be considered when tailoring the data that should be provided to end-users.

It is also clear from the literature that the way to communicate the feedbacks to the end-users involves two main approaches. Systemic: the house exists in a systemic context, and the data, retrieved by means of a smart grid, are presented at an individual household level and compared with the average system performance, Gasification: the feedback is presented by using elements and concepts that are typical in computer games and is often integrated in a graphical user interface (GUI). In the following sections, the most relevant technological devices and integrated software or applications today available on the market for improving the interaction between users and home appliances are presented, compared and discussed.

MQTT Protocol: Message Queuing Telemetry Transport 'MQTT' is a lightweight messaging transport protocol for constrained devices and low bandwidth networks. It is a publish/subscribe messaging transport for lightweight M2M communications in constrained networks .

MQTT is a de facto protocol for the IoT and hosted by OASIS open standards consortium and Eclipse Foundation. MQTT has a client/server model, where every sensor ordevice is a client and connects over TCP to a server called a broker

MQTT broker: MQTT broker is the heart of the system.It handles any publish/subscribe communication among the connected subscribed clients, which are the mobile application and the Phidget controller. Each connected clientcan be either subscriber or publisher. The broker is responsible for receiving all messages from the connected clients, filter them, decide which client is interested in this message and then sending the message to all interested subscribed clients message is published to the MQTT broker is known as a topic. Clients may subscribe to multiple topics. Every client subscribed to a topic receives every message published to the topic. For example, both MQTT clients mobile application and Phidget controller are subscribed to the broker with the topic 'House/door1'. Therefore, the mobile application and Phidget controller that are subscribed to 'House/door1' topic would receive every message published to this topic.

The hiveMQ Mosquitto implements an MQTT broker that enables the communication between subscribers and publishers through a topic subscription. the host broker for this application will be broker.hivemq.com, on the

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TCP port 1883. This is where the broker will receive the request sent from the android application and then distribute this information to all clients subscribing to the same topic such as the specific door lock (servo motor).

Phidget Advanced Servo 1-Motor: It is a "plug and play" building blocks for low-cost USB motor controllers. Itis configured as MQTT client publishing the sensor data to the MQTT broker and subscribing for the commands to

control the position, velocity, and acceleration of one servo**Servo Motor**: Is used as actuators in the prototype. Phidget module publishes the servo motor data under the topic 'House\door1'. A servo motor consists of a DC motor, a potentiometer, and a small analog circuit which acts as a controller to keep the motor in position. typically it has a range of motion somewhere between 0º and 180º, where0º represents a closed door and 180º represents a fully openeddoor.

Android Mobile application – The interface for the user,which enables to navigate across the application to decide which doors to open/close. Once a button is pressed this willsend a publish request with a message and topic for the MQTT broker to deal with.

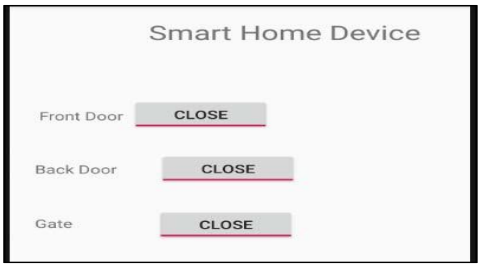
. Initially, when the user loads up the application on the homescreen there will be multiple different toggle buttons for eachof the different doors available to be open/closed. By default,all doors will be closed so each button will be on an *open* request. So, once the user presses the button, the motor or actuator. The servo controller has 3 pins per motor,

+5V, Ground, and Data. They all produce a PWM (pulsewidth modulation) signal to control the motor .

IV. IMPLEMNTINTAION AND RESULTS

The smart home devices are controlled through the android application. The interface of the application is shown in Figure 4a and 4b when both the doors are locked and unlocked respectively. In Fig 4a, the house doors are already closed and therefore the buttons display 'OPEN'. In Fig 4b, the house doors are opened and therefore the buttons display 'CLOSE'.

If the user wanted to open the Front door, for example, he/she can press the 'OPEN' toggle button for the Front Door on the android app. As a result, the Front Door lock should be opened and the corresponding button would display 'CLOSE'



I. Fig. 4a. The Android Application Interface (doors are closed) Fig. 4b. The Android Application Interface (doors are opened

ISSN: 2454-9665

Figure 5 and Figure 6 display the test results when open and close the Front Door for example. Figure 5, shows the test result of opening the 'Front Door'. When the 'OPEN' button in Figure 4a is pressed for the 'Front Door', the android application will publish the request 'OPEN' with a topic 'House/front door' to the broker. The broker will send this request to the subscriber Phidget controller of the same topic to open the front door by turning the servo motor to 180 degrees.

Figure 6, shows the test result of closing the 'Front Door'. When the 'CLOSE' button in Figure 4b is pressed for the 'Front Door', the android application will publish the request 'CLOSE' with a topic 'House/front door' to the broker. The broker will send this request to the subscriber Phidget controller of the same topic to close the front door by turning the servo motor back to 0 degrees.

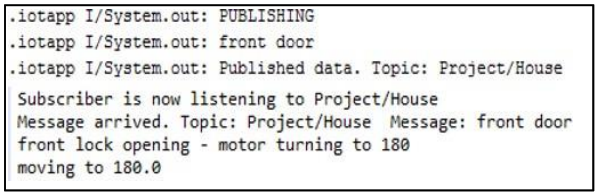


Fig. 5. Test Result of Front Door Opened

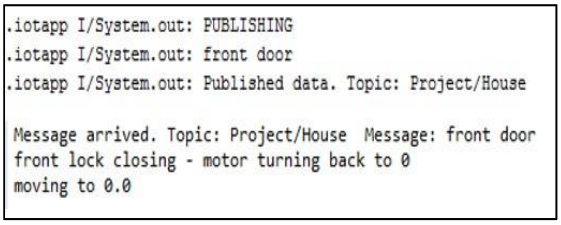


Fig. 6. Test Result of Front Door Closed

V. CONCLUSION AND FUTURE WORK

This paper presents a low cost IoT-based smart home automation system using an android application and Phidget controller to control home devices such as the door lock.

The MQTT protocol with MQTT broker enables the android application to communicate with the Phidget controller to control the connected servo motor to open/closethe door's lock.

For future work, the android application will be implemented with speech recognition voice control to controlhome devices efficiently.

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