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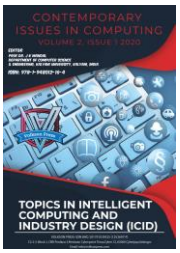

AN EFFICIENT VOICE ASSISTANT APPROACH USING IOT

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ABSTRACT

Internet of Things (IoT) is a simple concept that enables devices to communicate intelligently through the internet and turns devices into smart devices. IoT network comprises of physical objects or things implanted with software, sensors, electronics, actuators and web connectivity, which enables collection and exchange data. In this work, an IoT based proposed prototype is used to monitor the physical parameter such as room temperature, relative humidity etc. Additionally, using this proposed system a concept of a smart house is implemented where a standalone device will power up and controls the home appliances seamlessly. This is achieved with the help of intelligent automatic execution of the model after analyzing the collected data. The framework gives the controlling of home appliances remotely and provides security when the client is far from the place. This is done with the help of web server, mobile application & voice assistant-based approach. The feasibility of the proposed system is justified by developing hardware model and the result shows its successful implementation.

KEYWORDS

sensors, actuators, IoT, data logger, voice assistant, middleware. IFTTT, VOIP call, MQTT.

1. INTRODUCTION

The rapid technological advancements of IoT aspects have made it easier for firms to invest and establish IoT solutions. The major investments of IoT have been towards the development of smart homes and healthcare innovations. Venture Capitalist also invested largely in wearable technologies and user interfaces that control data from connected devices. In the developed countries, various companies are actively developing IoT solutions that foresees our upcoming future in which the elements of our daily life will be fortified with high-end low-cost microcontroller's, transceivers and utilization of innovative networking protocol stack that will make them able to interconnect with each other and with the user becoming an integral part of communication network. There is a lot of scope for IoT in India and Government has rightly recognized it and working towards it. The government has taken initiative and framed a draft policy to fulfil a vision of developing a connected, secure and a smart system based on our country's needs. Government's objective is to create an IoT industry in India of USD 15 billion by 2020. The IoT concept consequently aims at making the internet over mobile environment even more immersive and pervasive. Moreover, by enabling middleware protocol and interaction with a wide variety of devices such as surveillance cameras monitoring sensors, actuators, displays and home appliances the IoT will stimulate the development of a number of new services devoted to citizens, companies and public administration. This paradigm indeed finds application in many different domains, such as home automation, medical services and intelligent energy management system and many more. In addition, the IoT encompasses an extreme wide range of technology with the help of voice assistant and voice over IP (VOIP) based approach for comfort and usability towards human daily life. As the influence of technology in mankind has increased rapidly in recent decades, therefore IoT would take a crucial role to integrate automation technology using global network environment in a smart way. It integrates a growing number of smart organized devices and sensors that are often nonintrusive, apparent and opaque. Therefore, the services become much more mobile, scattered and complicated. For this reason, a lot of research has been done to integrate the data over different environments and supported by modular interoperable components. In this research work, an efficient IoT based prototype has been developed to control home appliances and capable to provide security under different wireless network environment with the help of voice assistant and VOIP call. The rest of the paper consists of proposed system requirements in section II, proposed system architecture in section III. Algorithm of the proposed scheme in section IV and performance analysis in section V. The work is finally concluded in section VI.

2. PROPOSED SYSTEM REQUIREMENTS

The proposed systems are classified into overall functions requirements & distinct system requirements. The overall function necessities are developed to execute system performance whereas distinct requirements are various process generated by consumer expectation. The validation code and privacy are ineffective requirements for the proposed system model.

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The projected system functions are characterized by:

- The ESP 8266 MCU based proposed prototype is fed with the sealed lead acid battery while charging is controlled by a PWM based charge controller with a solar PV module. During emergency power failure it is switched over to conventional grid power.
- The MCU Read the status of the GPIO pin and control the input-output of sensors and actuators with the help of publish-subscribe method.
- The server must explicate the statistics and convey the raw data to the centralized database. The storage data can be utilized by the analytical engine for generating reports graph and chart.
- Using cross-platform mobile web server the client should be able to view the generated graphical plot.
- Based on conditional programming (IFTTT)the VoIP call can be generated to alert the remote mobile user during failure of pre-assigned real-time sensor data created by the cloud-based remote server

3. Proposed System Framework

From the desired system framework the projected system architecture is designed and shown in Fig.1.It comprises of essential parts called hardware architecture, network architecture, middleware unit and consumer application segment. The hardware architecture consists of multiple numbers of sensors and actuators. These sensors measure temperature, humidity along with actuators in real-time and process it through a microcontroller. The microcontroller works as a control unit and as an interface between hardware architecture and network architecture through TCP/IP. The connection and coordination between the network architecture and its cloud-based web server are done through the middleware module. Lastly, the communication between server and user is achieved through the client application module. The details of all these modules are described explicitly in the following sub-sections.

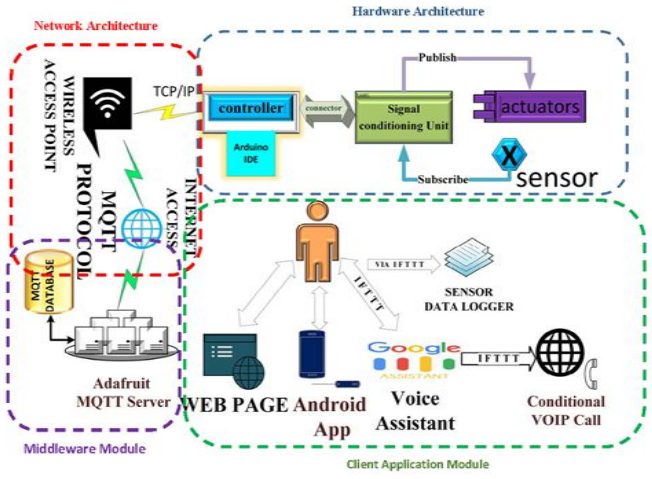


Figure 1: System architecture

3.1 Hardware Architecture

The hardware architecture is depicted in Fig.2. The proposed system comprised of the subsequent elementary unit-

- Sensor & Actuators: As per planned prototype, there is a control unit which is controlling & monitoring sensor & actuators in real-time. The sensor is connected to the microcontroller via serial port to measure the ambient temperature and humidity of the environment. The actuator is connected to the microcontroller through the optically isolated circuit. In our prototype, we have used high impedance MOSFET to drive the actuators. In addition, we can also replace the MOSFET with solid-state relay & triac to adjust on/off state of the device. A current sensor can be used to calculate power dissipation also.
- Low Power Microcontroller: A low power 32-bit microcontroller is a core device in the proposed system used as a control device & data acquisition unit that supervises the entire system. The microcontroller board supports directly flashing from the Universal Serial Bus port. It integrates the features of a wireless access point and a microcontroller unit in its core. It can be used as an access point and/or station, host a web server or connect to the internet to fetch or upload data. The details of the microcontroller used in proposed model are shown in Table.I.

Table 1: CPU Specification

Component	Description
GPIO pin	17
Analogue ports (ADC)	1 pin with 1024 step resolution
Memory	4MB flash, 112 kb RAM
CPU frequency	160MHz
Communication	I2C, SPI
Architecture	32 bits
WIFI frequency	2.412 GHz - 2.482GHz
Network Protocol	IPV4/TCP/UDP/FTP/HTTP/MQTT

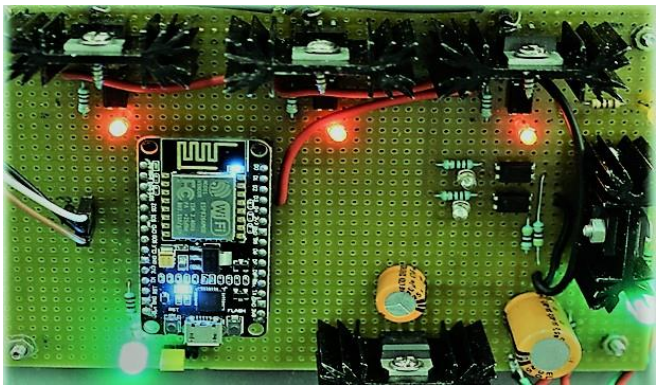


Figure 2: Hardware architecture

3.2 Network Architecture

The software architecture consists of a programming module, client application module & middleware module.

- Server: The open-source and freeware cloud server namely Adafruit is interfaced with the proposed prototype. Connection establishment is achieved with the help of TCP/IP 1883 standard port address configured against server port. In addition, the creation of valid user ID and pass-key using open-source embedded programming method enables the entire system more secure for remote log in purpose. The server runs in the MQTT protocol in the backend. It also includes a middleware broker, highly adoptable storage server, a web server and methodical engine server.
- Data Acquisition System: Data acquisition is the procedure of sampling of continuous signals that measure real-time physical conditions and convert the physical parameter into digital values that can be employed to a centralized processing system to perform a specific task. In our proposed model the data acquisition system performs two functions namely monitoring & controlling. In monitoring process, the observation of ambient room temperature, humidity has been efficiently done and as a result, the system generated realistic data is received to the remote user via the middleware module through the MQTT protocol. Simultaneously the controlling part receives the command from the middleware module to on-off or changing the PWM output for the connected appliances.

3.3 Middleware Module

To establish the request-response model in IoT based environment under heterogeneous domains of application a middleware module is incorporated in the proposed system. From the system perspective, this module needs to be reliable fall tolerant and optimized for resource consumption and also used for device discovery and management for device information. The server runs in the MQTT protocol. It includes an MQTT broking agent, highly adoptable storage server, a web server and analytical engine server.

- MQTT Server: Message Queue Telemetry Transport is an open standard protocol for publish and subscription method. This protocol is standardized by the International Organization for Standardization. The protocol is connection-oriented & works on top of Transmission Control Protocol. It provides an edge to edge communications between middleware and sensors/actuators. MQTT connection is always between no of sensors known as the client and remote server called the broker. No client is connected to another client directly. During the initialization of connection the client sending a special message called "CONNECT" to the broker. The primary responsibility of a broker is to receive all incoming messages generated by sensors node, filtering them and finally decide who is interested in the message and then forward the message to all subscribed clients. The unauthorized access of the broker is encrypted by an authentication key.
- Storage Server: In our prototype highly adoptable storage server is used as a data centre to store the sensors and actuators data & user's data. The user can download all the data anytime for backup. This server limits up to a certain amount of data.
- Analytical Engine: The analytics engine is used to calculate the risk of user activity, correlate it with other risky activity. A useful utilization software tool used to take smart decisions from the collected data. The user can analyses the data anytime to make certain decisions. The classifications used to generate graphs patterns of the activity of DHT11 sensor & actuators.

3.4 Client Application Module

This is where the client uses to communicate with the server. It consists of the webserver, mobile-based application, IFTTT.

- Web Server: It deals with a specified web address to control the appliances & monitor the sensors with a single click. This server needs right credentials i.e. Username, authentication code to access the database. Using the proposed prototype anyone can manage & analyses data into the server.
- Mobile-Based App: The proposed system able to display the real-time status of room temperature relative humidity and operate different switching function in conjunction with the middleware module. These mobile-based applications need server credentials to access the database. Then the application has to set up with topics name with different IDs to access all the sensors & actuators.
- *IFTTT:* IFTTT is a free web-based service to create chains of simple conditional statements. The Fig.3. shows the flowchart of conditional computing. In our prototype, we have used IFTTT to connect google assistant, google documents & VOIP calling service. We have configured such a way that all of our actuators can be controlled through voice assistant with customized commands which is depicted in fig.5. The sensors value will be stored google documents for future reference & conditional VOIP call will help us to alert in certain environmental changes.

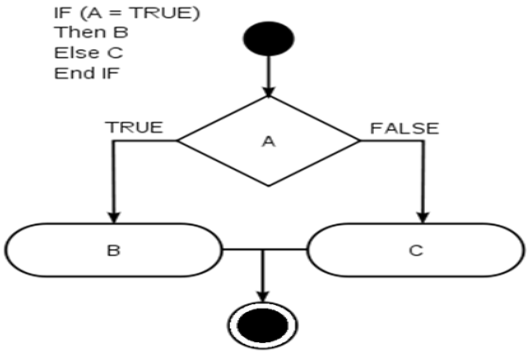


Figure 3: Flow chart of IFTTT

4. Algorithm of The Proposed Scheme

The microcontroller has been programmed with Arduino integrated development environment is a cross-platform application. Based on the system demands two types of algorithm is generated namely publish-subscription with addition to security and data network connection specific. The system flow diagram of the proposed model shown in Fig.4.

4.1 Sample Pseudo Code for MQTT Publish & Subscription Method:

```
Include esp 8266 WiFi.h file;
  Define i/o pin;
  Define local SSID/PASSWORD;
  Connecting to a local network
  {
   If connected then
Print IP address with connection status;
    Else
Wait for connection;
  }
    Feeding the MQTT topics;
  Verification of publish/subscribe method;
    Call MQTT function for topics;
  Declaration for 4-byte unsigned integer;
     While subscription=subscribed topic do
                If subscription=subscribed topic then
  string comparison "character";
    decide digital write high/low;
    // MQTT  connection
   Procedure MQTT_connect ()
       Define 8-bit integer;
        If MQTT connect then
 return;
Else
 Retrying for 3 attempts 5-sec delay;
If unsuccessful then
wait for watchdog timer reset;
```

4.2 System Flow Diagram of Proposed Model

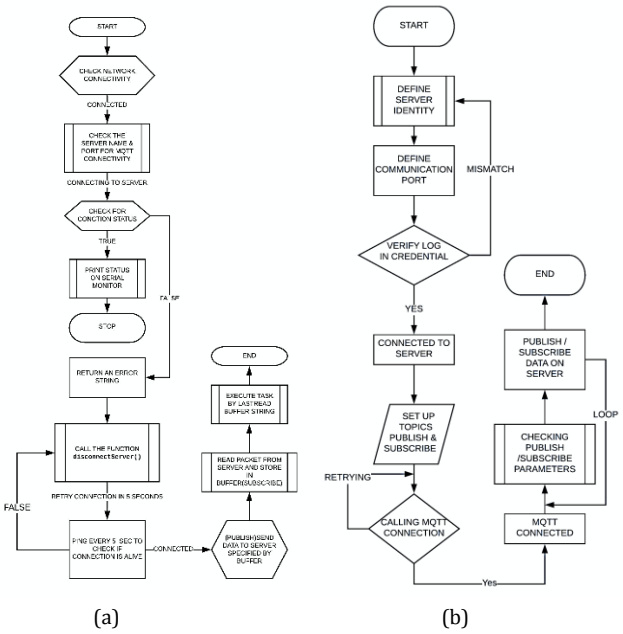


Figure 4: System flow diagram of the proposed model

(a) Publish-subscription method (b) MQTT connection method

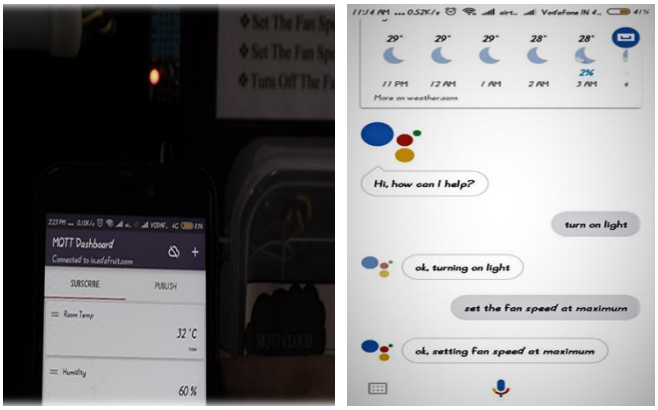
5. Performance Analysis

We have analysed the performance of the proposed system in a testbed environment. Though IoT uses different protocols such as HTTP, MQTT, TCP, and AMQP for communication between brokers & subscribers, we preferred MQTT because of its versatility and lower acknowledged delivery time. A mobile-based application through MQTT dashboard is shown in Fig.5(a). This dashboard depicts the middleware module of the designed system. A voice assistant output using IFTTT is shown in Fig.5(b). We have configured in such a way that all of our actuators can be controlled through voice assistant with customized commands which is depicted in Fig.5(b). The sensors value will be stored in the MQTT server as well as Google documents for future reference and conditional VOIP call will help us to alert in the certain environmental changes. The performance of the proposed framework is analysed in two phases. At first phase, the read/write performance of the storage server has been checked. In the second phase, the overall server response time for client-

broker-client paradigm has been validated for different communication network perspective. Server response time of varying range in case of broadband is shown in Table II.

Table 2: Storage Server Read & Write Performance

Types of Response	Time
Maximum response time	689 ms
Average response time	533.5 ms
Minimum response time	378 ms



(a) (b)

Figure 5: Client Application Module

(a) Mobile-based application (b) Voice assistant by IFTTT

As a part of performance testing, we have used two devices in a different location to simulate latency test for existing 3G, 4G & broadband network. This is reflected in Fig.6. This represents the response time of the server in case of a sensing query is generated for all types of networks. From Fig.6 it is cleared that the response time of the server is more in case of the 3G network compared to broadband or 4G. This is because of achievable higher data of communication for broadband or 4G in comparison with 3G. The practicability of the model is done through the implementation of its functional prototype and is represented in Fig.7.

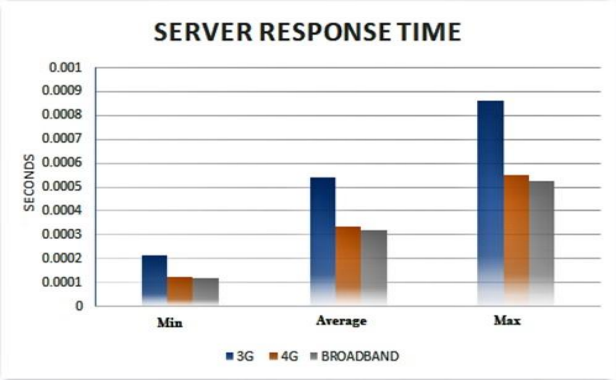


Figure 6: Effective response time over different network

Figure 7: Functional prototype

6. Conclusion

Innovative uses of IoT technology in a smart home not only bring advantages to the user to access wide ranges of control of different appliances but also saving large amounts of energy with the help of accessing heterogeneous IoT data especially in a mobile environment of real-time IoT application system. In our prototype, multiple actuators & sensors network is efficiently controlled and monitored by the MQTT server on a real-time basis. The system empowers users to remotely monitor & control devices and take necessary action within a few milliseconds with the help of mobile-based application and voice command. The efficacy of the model is justified by its performance. As a future enhancement, this work can be improved by considering microcontroller boards with higher data rate and providing more GUI access.

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