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MODELLING AND SIMULATION OF A BUDGET-FRIENDLY, SECURED AND INTELLIGENT HOME AUTOMATION SYSTEM USING INTERNET OF THINGS FOR THE AGED AND DISABLED

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ABSTRACT: *Intelligent Home Automation System is one of the subjects that is gaining traction and popularity due to its numerous benefits across the globe today. Home automation is the process of remotely monitoring and controlling household appliances and devices. With the Internet's and its applications' never-ending growth, there is a lot of promise and scope for remote access, control, and monitoring of network-enabled appliances and devices. This paper developed an easy-to-use, secured and intelligent home automation system; capable of remotely monitoring and controlling appliances in the home, by integrating it with an affordable, flexible, versatile, open-sourced, single-board microprocessor and yet scalable Arduino Uno. The work was carried out in the following stages; First, the Arduino Uno was set up with Bluetooth and Wi-Fi connections, and Android device interfacing. Secondly, upon successful connection and configurations, the system successfully worked with the home model developed. Lastly, a unique yet simple user interface was created using the Android MIT App inventor, thereby completing the system design. The intelligent home automation system was fully simulated given the above steps, ensuring that everyday use of home appliances is monitored and controlled for a more secure, seamless and intuitive user experience. The paper also examined a number of intelligent home automation systems and technologies from a variety of defined perspectives. It focused on the home automation idea, in which smart devices are used to integrate home automation systems and technologies with a central single-board – microprocessor (Arduino Uno); Life is becoming simpler and easier in all aspects due to advancements in automation technologies, particularly in homes and working environments.*

KEYWORDS: Intelligent, System, Home, Automation, Appliance, Arduino Uno, Internet, Home Owner.

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INTRODUCTION

The Internet of Things (IoT) is commonly perceived as a notion wherein a gadget is allocated an IP (Internet Protocol) address, enabling anyone to pinpoint that gadget on the web via said IP address (Alkar & Buhur, 2015). Both autonomous and electronic contraptions are endowed with distinct and unique identifiers (UIDs) with the capacity to transmit information across a designated interconnectivity necessitating direct human-to-computer or human-to-human interaction. Essentially, it originated as the "Internet of Computers or devices." Past and ongoing exploration has predicted a skyrocketing proliferation of the quantity of "things" or gadgets linked to the network. This posterior interconnected framework is dubbed the "Internet of Things" (IoT). Modern advancements in innovations facilitate and permit the utilisation of hands-free control habitats such as Bluetooth and Wi-Fi, which have empowered diverse gadgets and appliances to possess the capacity to establish connections with one another (Arun et al, 2018).

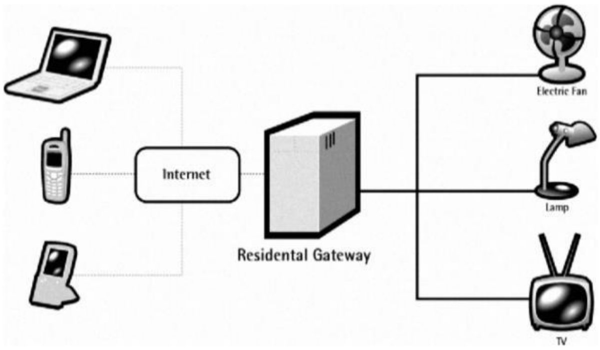

Figure 1: Overview of an intelligent home

IoT represents an evolving technology aimed at enhancing communication between technological devices and various sensor types to introduce novel applications that enhance convenience in daily life. Automated devices find extensive usage across various sectors, where they are deployed to oversee numerous operational processes. (Ciubotaru-Petrescu, Chiciudean, Cioarga & Stanescu, 2016).

Homes in this dispensation are poised to become increasingly self-regulated and automated, enhancing convenience, particularly in personal residences. Consumers and homeowners can leverage home automation systems to oversee a multitude of electrical devices. Various renowned home automation products offer wired connectivity. However, unless meticulous planning and execution occur during the building's actual development, this may not alleviate confusion. Deployment costs are escalating, particularly for structures not initially designed with automation in mind. Conversely, wireless networks play a pivotal role in streamlining process automation. Wi-Fi and other wireless innovations have made significant strides in this regard.

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EMPIRICAL REVIEWS OF RELATED LITERATURE

Contemporary electronic devices found in typical household settings typically operate as standalone hardware units. The aim of home automation systems is to foster intelligent environments by ensuring the compatibility and seamless integration of these individual devices (Arun, Lexmitha, Aruna, & Swathika, 2021).

Previously, extensive research has explored a wide array of fields ranging from security and technological advancements to architectural design and energy efficiency, owing to the interdisciplinary nature of IoT. Notably, a plethora of IoT solutions have been devised for the benefit of elderly and disabled individuals in the realm of healthcare, with numerous applications documented in the literature (Vignesh & Kavin, 2020).

In another research conducted by Arun et al. (2020), an IoT-enhanced intelligent home system was formulated to enable remote monitoring and control of household environments. Within this study, various applications including smart lighting, gas detection, and intrusion detection were implemented utilizing Arduino hardware.

Arun et al. (2021) devised a novel solution leveraging an assortment of sensors to regulate several home appliances such as lighting, fans, doors, energy consumption, and gas levels.

Additionally, this solution encompasses a systematic framework encompassing system design, objectives, and implementation specifics. The framework employs temperature sensors initially for its development, though alternative sensors can be integrated as needed. These intelligent home devices equipped with sensors possess the capability to self-configure and function independently of human involvement. This endeavour prioritizes authentication and automation of intelligent home devices while streamlining encryption-decryption processes. The system bypasses the local gateway mentioned in the existing system to provide better security for intelligent home devices and sensor data and save computation overhead.

Vignesh and Kavin (2020) outline an approach aimed at establishing an affordable Home Automation System (HAS) through the utilization of Wireless Fidelity (Wi-Fi). This method encapsulates the notion of interconnecting intelligent gadgets. A Wi-Fi-based Wireless Sensor Network (WSN) is devised to oversee and manage environmental, safety, and electrical factors within a smartly interconnected residence. The HAS comprises various components including temperature and humidity sensors, gas leakage detection, fire alarm, intruder alert, rain-sensing, load switching and regulation, as well as voltage and current monitoring.

The primary objective of this Intelligent Home Automation System (IHAS) is to facilitate monitoring and control of devices through a Smartphone application and internet connectivity.

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CONCEPTUAL FRAMEWORK

As evident from the aforementioned relevant research, intelligent home automation systems have been created employing various sensor varieties, MCU, and SBC hardware. Nevertheless, these inquiries are constrained as they scrutinize smart home IoT gadgets within controlled test settings or on a diminutive scale. Given that most applications are tailored towards specific solutions, they merely illustrate fragments of home automation systems. Conversely, in the devised framework, simulation applications and software enable the development of large-scale programs by facilitating the incorporation of additional devices and categories.

EXISTING SYSTEM

Numerous researchers and teams have conducted thorough investigations into the utilisation of intelligent home technologies to aid elderly and differently-abled individuals. These studies have outlined the obstacles associated with intelligent home systems, particularly in their capacity to assist the elderly and handicapped. The overarching objective is to mitigate handicaps and provide assistance to individuals, thereby promoting greater independence for as long as feasible.

THE DEVELOPED SYSTEM

However, the paper underscores the merits of adopting a wireless standard. The internet, WiFi, and Bluetooth represent global standards for connecting a diverse array of devices, readily accessible on most handheld gadgets. This technology boasts user-friendliness in setup and operation, coupled with robust security measures through data encryption employing a 128-bit shared key. Recent advancements in Radio Frequency (RF) systems, such as Bluetooth and ZigBee, have propelled their popularity. Nevertheless, a drawback of the system lies in its limited communication range, particularly evident in Bluetooth technology. Despite this, these products offer a more dependable short-range network compared to previous Infrared devices plagued by interference and security concerns. However, RFID tags, while offering benefits, tend to be costlier, less reliable, and tailored to specific applications, lacking a one-size-fits-all solution.

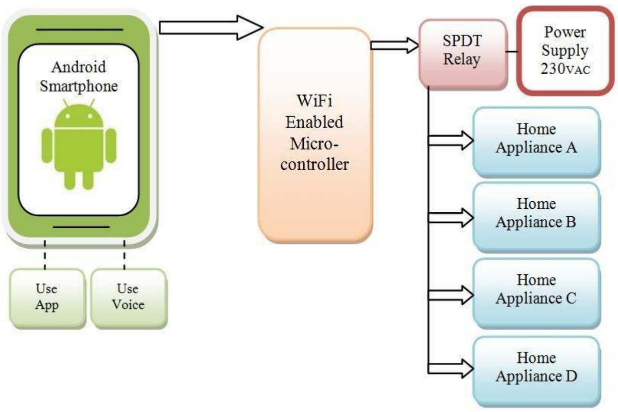

Figure 2: IoT Block diagram of an IHAS

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BENEFITS OF THE DEVELOPED SYSTEM

The adoption and use of the intelligent home automation system gave numerous potentials and outlines a given amount of importance to homeowners captured viz;

i. Healthy and thriving people cannot readily applaud the need for automation, the way the disabled and elderly (aged) do; who readily understand and feel the difficulty of switching ON or OFF simple home and household appliances like lights, fans, TV sets, etc.

ii. Energy costs and consumption are harnessed by automating power usage by simply switching of electrical appliances hands-free.

iii. Implementing wireless technology is significantly simpler and more cost-effective since nodes can be positioned virtually anywhere, unlike in the case of cabling or wiring, which predisposes one to harm.

WHERE IS THE ENERGY WASTE? Source: www.eia.gov.ng

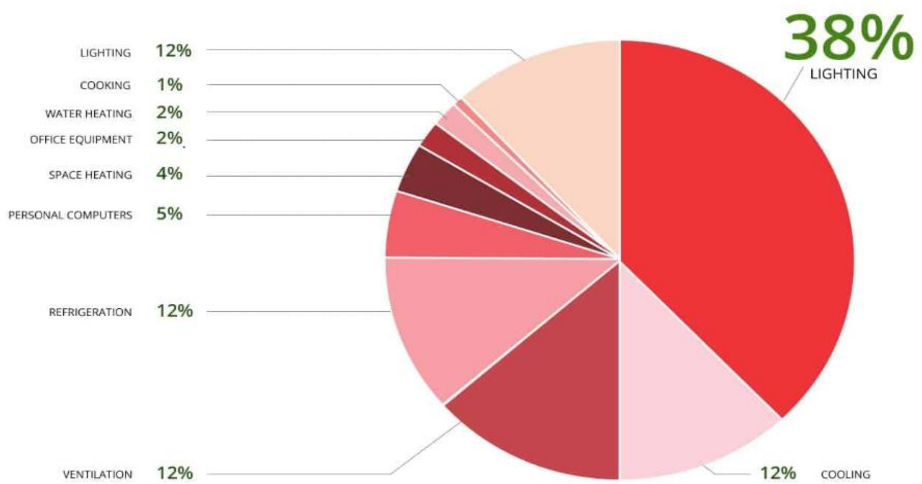

Figure 3: A Chart Showing Energy Waste in Home Appliance Usage (www.eia.gov.ng)

iv. The incorporation of internet-enabled devices (e.g., WiFi etc.) is of importance since almost every smartphone and devices have this application on them. These gadgets can be seamlessly incorporated, providing effortless accessibility as long as conditioning is kept/maintained, and the device is within the network/signal range.

v. Personal safety has been enhanced.

vi. Time, effort and resources are managed and conserved.

vii. Increased heightened autonomy and enhanced management of the surroundings.

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HOME AUTOMATION SYSTEM

Home automation entails the automated management of electronic devices within your residence. These devices are linked to the internet, enabling remote control. Through home automation, devices can activate each other, eliminating the need for manual control via an application or voice-activated assistant (Intel, 2020).

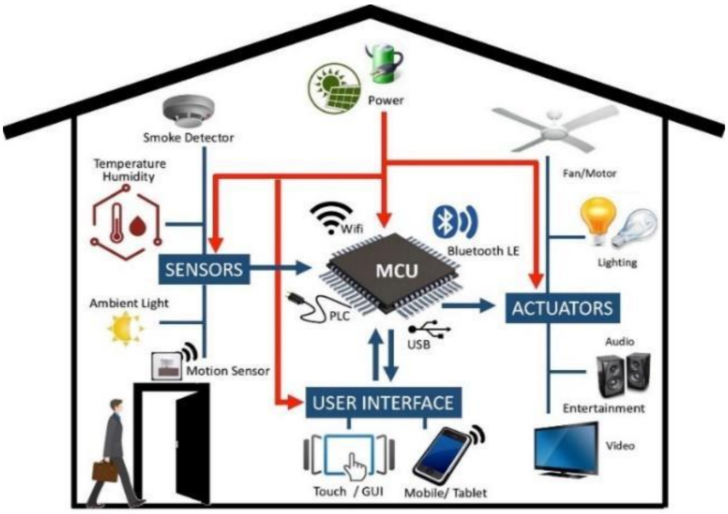

Figure 4: Overview of Intelligent Home Automation System Showing Devices Connected

IOT Vs. HOME AUTOMATION

The term Internet of Things (IoT), often abbreviated as IoT, encompasses any internet-connected device that deviates from the norm; for instance, a smart or intelligent light bulb controllable through a mobile application. All home automation gadgets fall under the category of IoT devices, capable of being automated to activate one another. So, while IoT refers to the devices themselves, home automation is what you can do with the IoT devices to make your life just a tad bit easier (Ramlee, Othman, Leong, Ismail & Ranjit, 2013).

Home automation utilises electronic interfaces, these devices can be remotely managed through controllers, including voice assistants like Alexa or Google Assistant, or via dedicated applications. A multitude of these IoT devices are equipped with sensors designed to detect changes in motion, temperature, and light, thereby providing users with insights into the device's surroundings. To effect physical alterations to the device, users activate actuators, which are physical mechanisms such as smart light switches, motorised valves, or motors that enable remote control of devices.

Home automation works on three levels:

i. **Monitoring**: Monitoring means that users can check in on their devices remotely through an app. For example, someone could view their live feed from a smart security camera.

ii. **Control**: Control means that the user can control these devices remotely, like panning a security camera to see more of a living space.

iii. **Automation:** Finally, automation means setting up devices to trigger one another, like having a smart siren go off whenever an armed security camera detects motion.

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Table 1: Loup Ventures Annual Digital Assistant IQ Test Results (2023)

Voice Assistant	Correct Answers	Perception Query
Amazon's Alexa	79.80%	99.90%
Google Assistant	92.90%	100%
Apple's Siri	83.10%	99.80%

INTERNET OF THINGS (IOT) FEATURES

Below are a few features of the Internet of Things (IoT);

i.	Remote control	App	Geofencing
ii.	Voice assistants	IFTTT	Scenes
iii.	Schedules	Triggers	Home and away modes

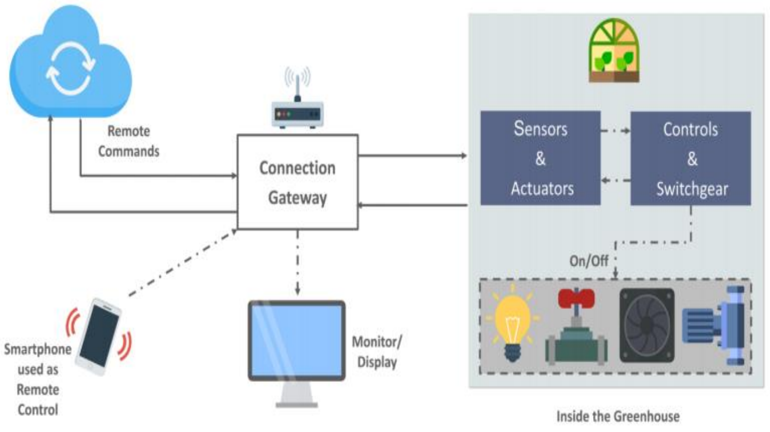

Figure 5: IoT Controlled Greenhouse Environment

METHODOLOGY

The fundamental concept behind IoT revolves around enabling internet connectivity to facilitate data exchange, regardless of the scale of the devices involved. The protocols at the application layer of IoT should tackle and resolve certain challenges encountered in IoT network communication. This is crucial because the data utilised by IoT systems tends to be more intricate compared to traditional networking systems (Lou, et al., 2021).

General System Description

Frequently utilised smart home items include Locks and Security Systems, Thermostats and Cooling Devices, Lighting Fixtures, and Carbon Monoxide Detectors, as illustrated in the diagram (Loup Ventures, 2023). bIoT, abbreviated as "Internet of Things," refers to the interconnection of various objects with the internet. It facilitates the management of both local and remote devices through the incorporation of network technologies (Lou et al., 2021). IoT

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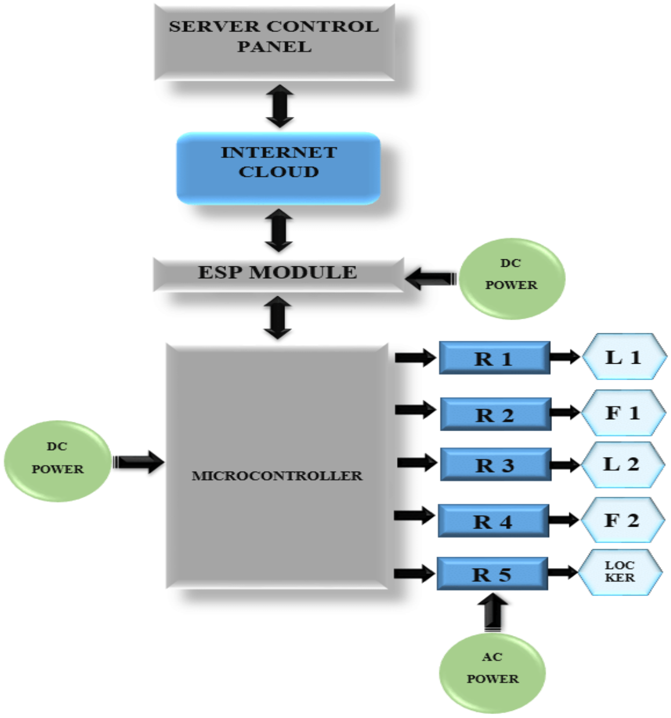
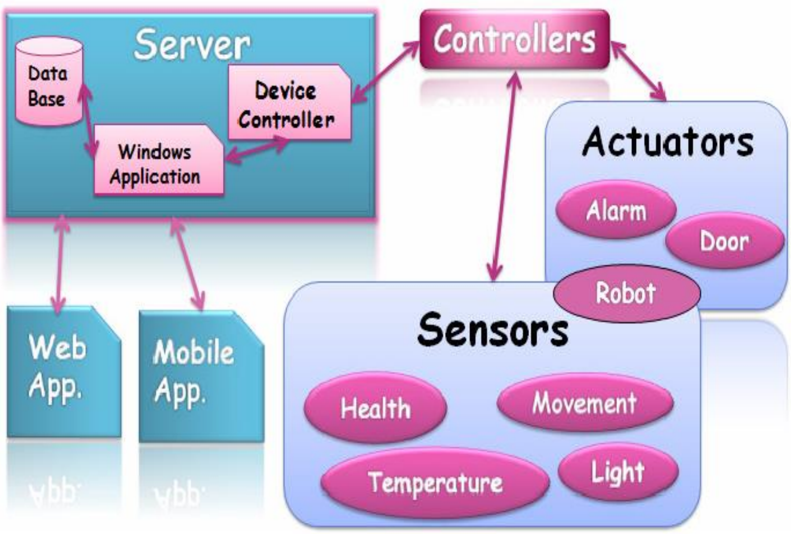
links everyday devices within our vicinity as well as those accessible over the internet, streamlining communication among them. This burgeoning technology aims to enhance communication between technological devices and various sensors, introducing novel applications that simplify daily life.

The Developed System





Figures 6 and 7: Schematic Diagram for IOT Based Home Automation System & State Diagram of the Intelligent Controlling System respectively.

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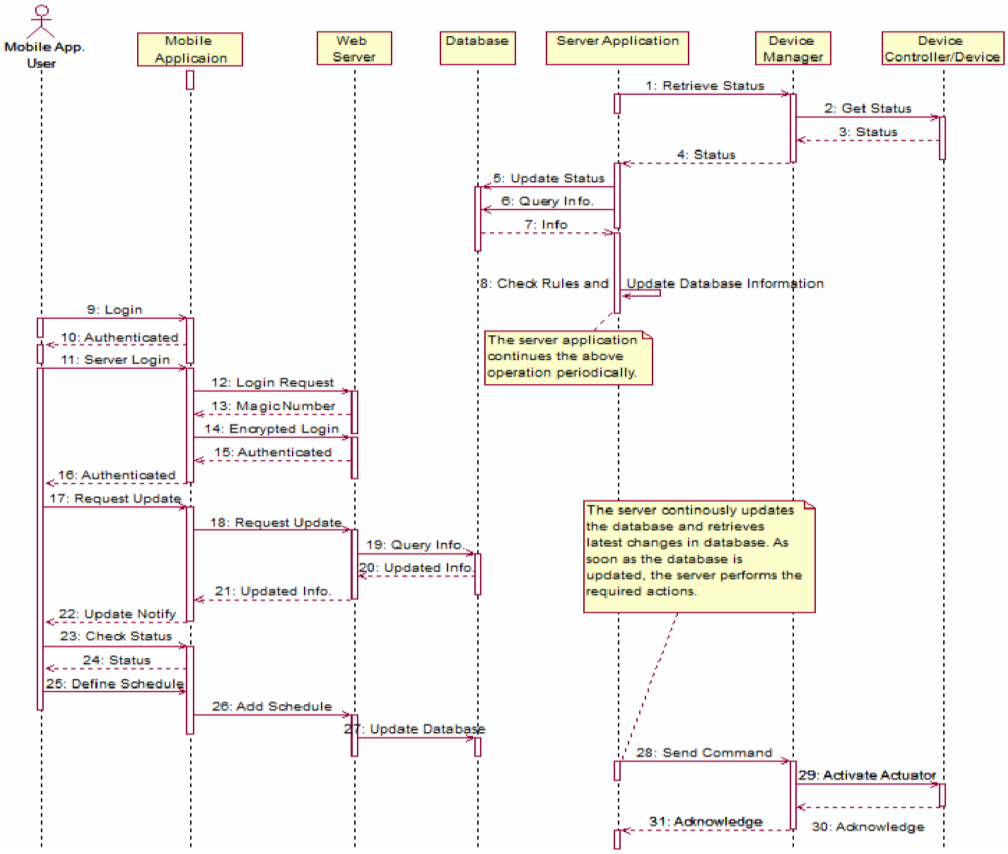

Figure 8: Activity Diagram of the Intelligent Controlling System.

Overview of the Developed System

The paper entails the development of a prototype for an enhanced home automation setup, employing IoT technology and microcontrollers to interconnect its components. The objective is to create a home automation system managed through the ESP8266 Wireless Fidelity program desegregated with IoT. The servo motor is utilized to regulate the door-locking mechanism within this system. Through this setup, users can wirelessly connect to various devices via the Wi-Fi module and issue commands to the server. In contemporary times, technology has progressed to the extent that modern residences are equipped with home automation amenities, albeit at a considerable expense often beyond the means of many individuals. The aim of this paper is to introduce a more efficient, dependable, cost-effective system that can be operated from any location without posing any risks.

The main schematic diagram of this paper is shown in figure 6 above; To manage household appliances from any distant location by sending commands over the network defined. The packet can be regulated, monitored and controlled using a web interface equipped using customisable homeowner options. The complete state diagram is shown in Figure 6 above; where, in this setup, the ESP Wi-Fi module serves as the primary control unit. Users can transmit commands via the designated IP address, which are then relayed to the Wireless Fidelity module. The module was engineered to connect to the network through an available hands-free network. The signal received by the Wireless Fidelity module is implemented by an embedded application therein. The Wireless Fidelity module interfaces with TRIAC and

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Optocoupler components, facilitating the switching on and off of loads in accordance with the commands received. The current status of the load (ON or OFF) is then displayed.

The activity diagram seen in Figure 7 below illustrates the operational concept of a control system in this context. The system is linked to Wi-Fi, enabling users to access a web page and transmit commands to the server upon login. The microcontroller regulates the activation and deactivation of relays in accordance with the commands received. As the outputting devices operate on Alternating Current power, where the relay functions as a conduit, supplying Alternating Current power when the signal is ON and cutting the flow when OFF. The coding and simulation processes are to be executed based on the schematic, state, and activity diagrams depicted in figures (6), (7), and (8) respectively.

IOT COMMUNICATION PROTOCOLS

Francis, Wilfred and Sekar, (2019) revealed that one of the most important issues to be considered in home automation system development is determining the communication protocol. Communication protocols are application layer protocols that allow data to be transported in IP packets over the network. Different communication techniques are used in the development of IoT solutions. In the classification of IoT communication protocols, it can be seen that there are protocols communicating via a central server (publish/subscribe method) and protocols that communicate directly without an intermediary server (request-response method).

MQTT, which is the most used protocol in the development of IoT solutions, is a TCP-based IoT application protocol that works in the broadcast/subscriber architecture. Internet-based MQTT resources can be used at the stage of designing a home automation system prototype. Various licensed or free resources are available for this purpose. Also, local applications running on SBC hardware can be used. Another protocol used in IoT applications is the CoAP protocol which runs on the Request architecture (Francis, Wilfred & Sekar, 2019).

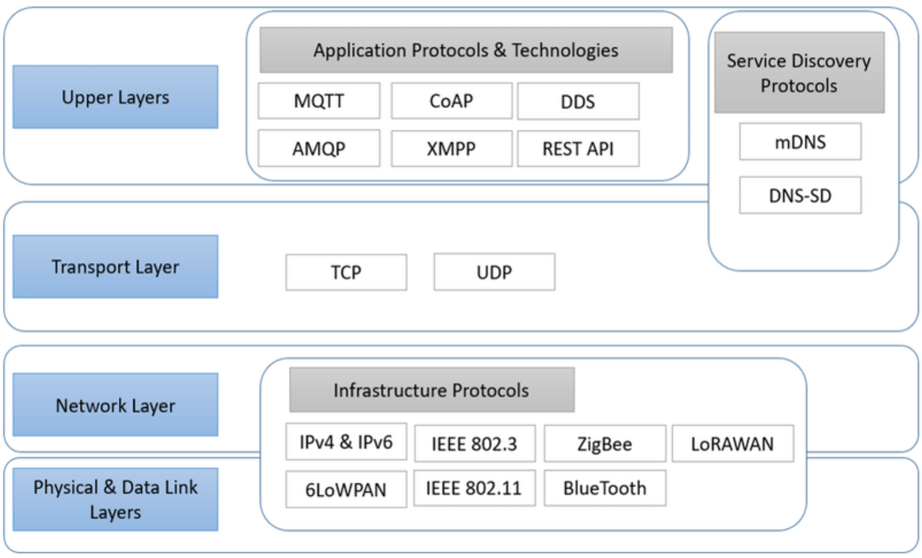

Figure 9: IoT Protocols in IHAS

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SIMULATION-ASSISTED HOME AUTOMATION SYSTEM DESIGN MODEL

Within the scope of this paper, a six (6) phased spiral software development model or approach consisting of six steps as shown below was used to show the development of a home automation system done by simulation.

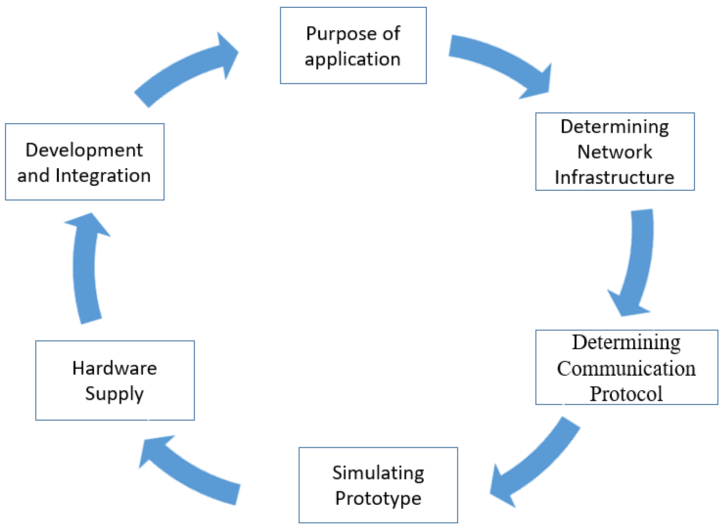

Figure 10: Spiral Simulation-Supported IoT Solution Design Steps

RESEARCH DESIGN

The initial phase commenced by selecting a research framework that effectively tackles the research inquiries. Decisions made at this juncture encompass determining the type of data to be gathered, the methodologies for data collection, identifying potential participants, and outlining the data analysis approach.

Data Collection Approaches

In order to achieve the set objectives, the paper used both qualitative and quantitative approaches to data collection was employed. This approach is aimed at enriching the research endeavour with comprehensive knowledge and insights necessary for developing the requisite system. In this research endeavour, data gathering involved conducting observations and engaging in background reading.

Observations

Observation entails the sight of individuals performing their tasks in a natural environment, offering the analyst a deeper comprehension of the job compared to interviews. Additionally, observation provides insights into the information individuals utilise to perform their tasks. Successful observation requires adequate preparation (Manikandan, Karthik & Arun, 2015). Furthermore, the paper observed how individuals interact with their mobile phones within a

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specific locality, assessing the potential significance of the system to users in their immediate surroundings.

Background Reading

The paper entailed an extensive literature review to acquire insights into how previous scholars and researchers addressed analogous issues. Through this process, a deeper comprehension of the problem and the void to be addressed was attained. The data is primarily sourced from digital repositories, articles, and established literature.

Hardware Technologies and Design Requirements

The intelligent home automation system using IoT is to be implemented using:

i. WiFi Module
ii. Hc-06 Bluetooth Module
iii. Internet (of Things)
iv. Defined Network
v. Arduino microcontroller
vi. Smartphone
vii. Relays
viii. Light Bulbs
ix. Fan
x. Breadboard
xi. Jumping Wires
xii. Resistors
xiii. Diode

Design Methods

At the stage of determining the purpose of the application, the purpose of the IoT solution to be developed is determined. Examples such as the motion-sensitive home security system and the air conditioning of the living area are determined at this stage.

SIMULATING THE PROTOTYPE

According to the purpose and technology determined in the previous stage, the prototype to be developed in the simulation software is simulated. According to the problems encountered, changes can be made in the previous stages, or if the simulation result is successful, the next stage can be passed. At this stage, it is evaluated again whether the used bandwidth is calculated and the communication protocol works efficiently and in accordance with the purpose.

Provision Of Necessary Hardware:

After the success of the previous stage, the hardware used in the simulation is provided. The solution developed during the development and integration phase of the system is implemented. At this stage, a new system or integration into an existing system can also be made.

ELECTRONIC HARDWARE COMPONENTS AND EQUIPMENT

This stage involves incorporating the hardware electronic elements into both the Raspberry Pi and Arduino, configuring them for remote access. For this purpose, the paper utilizes a DLink 2750u router with an ISP connection. The hardware communication occurs via WiFi, with all devices linked to the Arduino Uno through Ethernet. The Android application oversees the

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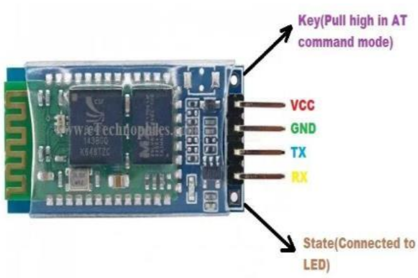
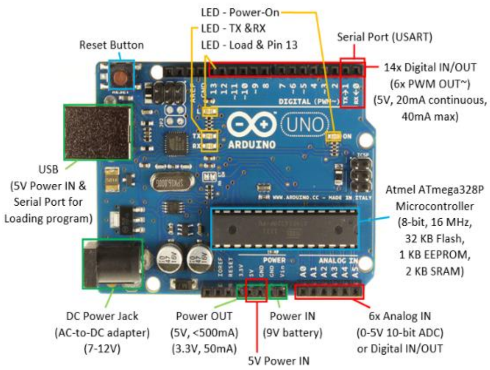
operation of integrated peripherals, including cameras, door sensors, and lighting devices. These components are listed thus;



Figures 11, 12 and 13: The 12V, 2A AC-DC Power Adapter Converter, Buck Circuit Converter & HC-06 Bluetooth Module respectively.



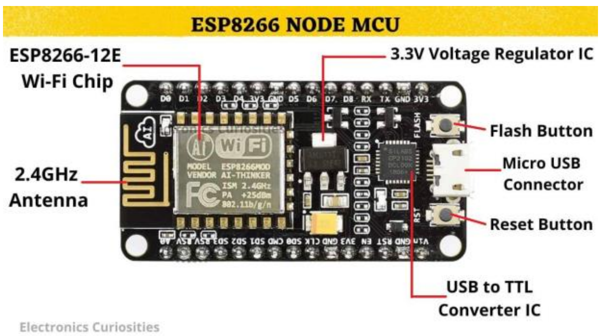


Figure 14: The Arduino Uno Board Figure 15: ESP8266 Node MCU Board

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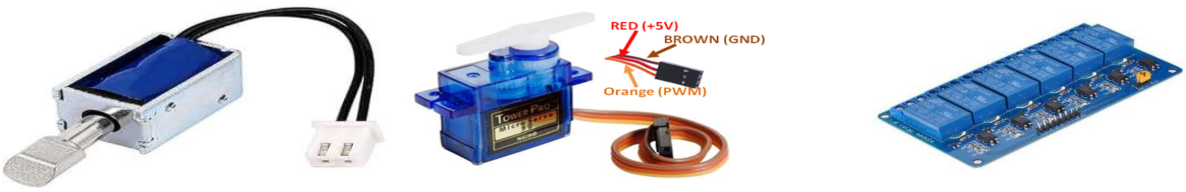

Figures 16, 17 and 18: The 12V Solenoid Lock, Servo Motor SG90 & 6 Channel DC 5V Relay Module respectively.

Table 2: Node MCU Index ↔ GPIO Mapping

Pin Name on Node MCU Development Kit	Esp8266 Internal GPIO Pin Number	Pin Name on Mode MCU Development Kit	Esp8266 Internal GPIO Pin Number
0[*]	GPIO16	7	GPIO13
1	GPIO5	8	GPIO15
2	GPIO4	9	GPIO3
3	GPIO0	10	GPIO1
4	GPIO2	11	GPIO9
5	GPIO14	12	GPIO10
6	GPIO12		

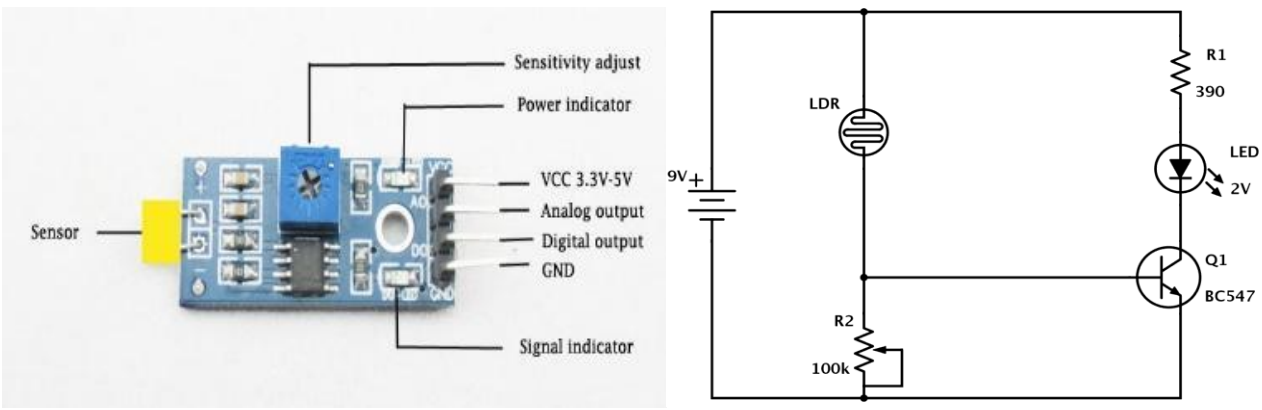

Figure 19: Photosensitive Sensor Module & Schematic Diagram

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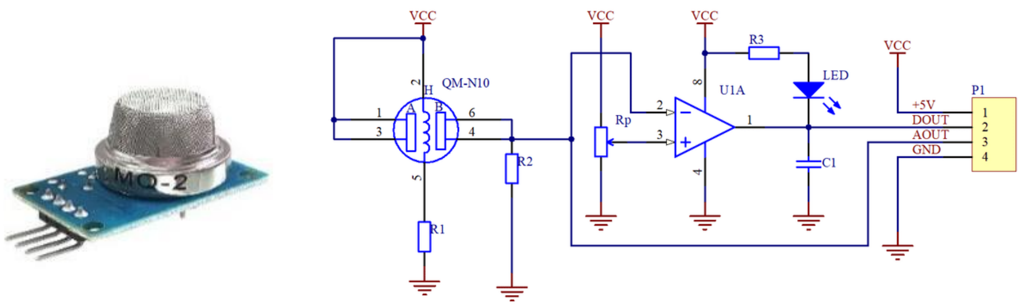

Figure 20: ADIY MQ2 Smoke/Gas Sensor Module & Schematic Diagram

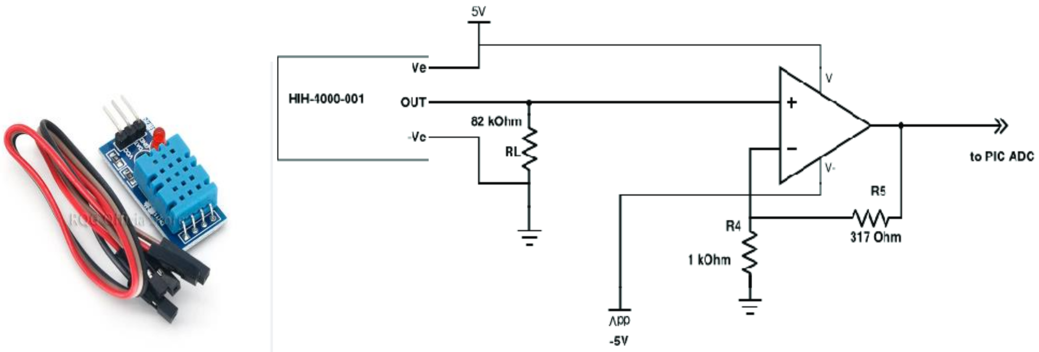

Figure 21: DHT-11 Digital Temperature and Humidity Sensor and Schematic Diagram

INTERFACE

After the template is generated, the next step involves amalgamating all development efforts to form a comprehensive interface. The Python code oversees the roster of controls to be presented to the user. The software suite offers diverse perspectives for managing various facets of the controls, encompassing their administration and appearance on specific client software. The Servlet application operates on the OpenShift PAAS platform, with the Arduino Uno microprocessor and users acting as clients. Leveraging the robust capabilities of OpenShift, a more sophisticated user interface was developed and implemented.

Software

The subsequent section elucidated the backend code generated for the applications. Flowcharts depicting the code's progression aided in conveying its sequence. Both the server and client applications are scripted in Python, serving as the conduit for Raspberry Pi to interface with lights and sensors. The forthcoming software employed a combination of built-in functions and user-defined interfaces and methods.

Software Description

In this paper, there are two primary components of the software to be developed: one for the Android application, serving as the frontend, and the other for the software operating on the Arduino Uno, functioning as the backend. The Android application is tasked with transmitting

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client request commands to the microcontroller either wirelessly or through Bluetooth. In response to these requests, the microcontroller dispatches appropriate commands to control home or household appliances.

ANDROID APPLICATION DEVELOPMENT

The smartphone selected for use in this paper is the Infinix Note 8 Pro, operating on Android OS version 10. The Android application is developed using the Android Development Kit. This application is compatible with Android versions 5.0 through 11, ensuring support for fingerprint sensor functionality. Integration of this feature into the developed system enhances security measures.

Functional Requirements

These statements outline the services that the system is expected to offer, detailing how it should respond to specific inputs and behave under particular circumstances. Functional requirements elucidate the anticipated behaviour of the system, which can be articulated as tasks, functions, and services. The following statements delineate the anticipated outcomes of the developed system:

i. Users have the capability to scan and store their fingerprints or passwords for authentication purposes.

ii. Authorized users should be able to regulate the appliances.

iii. New users are able to pair their mobile devices with the hardware for seamless Bluetooth connectivity.

iv. The system is expected to produce reports on the status of devices and/or their energy consumption.

Non-functional Requirements

These requirements do not depict the precise behaviour of the system; instead, they unveil how the system operates. They represent the limitations of the application. Listed below are the non-functional requirements of the developed system:

i. **Confidentiality** - Data in transit are kept secure as it is prone to interception. The system provides necessary security to the users and data must be free from errors.

ii. **Reliability** - The system is able to provide specified services to authorized users.

iii. **Availability** - The system provides service whenever a valid user needs it.

iv. **Portability** - The system application is easily transferred to different Android smartphones stress-free.

v. **Usability** - the application interface is user-friendly such that a naive user must feel free to operate it.

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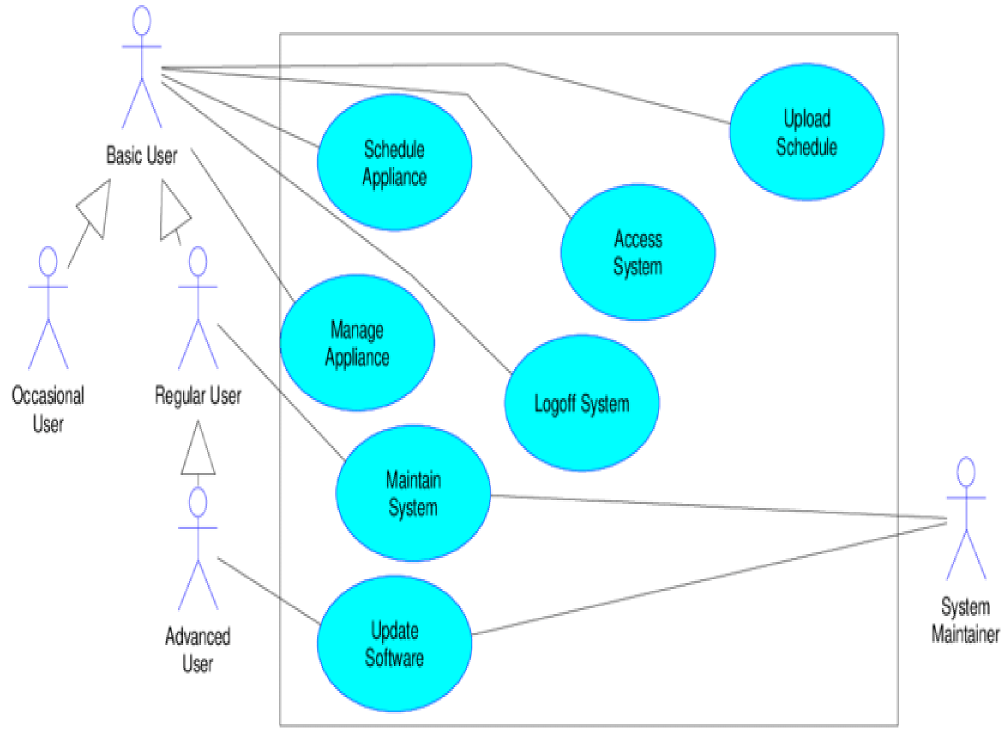

Figure 22: Use a Case Diagram of the Developed System

Schematic Diagram of The Developed System

The block diagram illustrates the operational structure of the entire paper. The Node MCU unit serves as the microcontroller or primary control unit of the system. Users employ the mobile application to issue commands for the operation of appliances. The mobile application interprets user commands in either voice or switch mode, transmitting signals to the Node MCU unit via a wireless network established through Wi-Fi communication. Consequently, the Wi-Fi module (inherently integrated into the Node MCU) facilitates the microcontroller in establishing Wi-Fi communication with a device, enabling it to receive commands from the application over the wireless network.

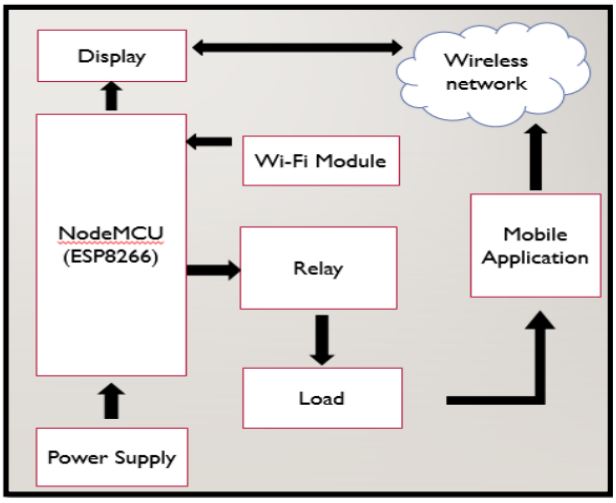

Figure 23: Schematic Diagram of The Developed System

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Upon receiving the signal, the Node MCU proceeds to activate or deactivate the appliance with the assistance of the relay. Physically, the Node MCU, relay, and the ultimate appliances are interconnected. A power supply unit provides power to the microcontroller, relay, and the appliances. Additionally, a display unit is incorporated to indicate the status of the application.

RESULTS, IMPLEMENTATION AND DISCUSSION

The system crafted during the execution facilitates the manipulation of household devices through pre-existing gadgets such as smartphones or home computers. The interfaces are user-friendly, straightforward, and offer a more user-friendly interaction. Additionally, the devices seamlessly integrate into existing systems and demand minimal to no expertise for installation. This endeavour also illustrates the diverse range of possibilities for home automation implementation, extending beyond previously discussed scenarios. The technology employed can be applied across various contexts necessitating sensor and household appliance utilization. This paper effectively engineered a system that interfaces with a smartphone (mobile) via Arduino Uno to oversee door sensors, light and fan controls, smoke detection, dust and air pollution monitoring, and lastly, water quality and level supervision modules. Nevertheless, numerous other potential applications could leverage the outcomes of this endeavour.

Sample Scenario

A residence equipped with an IoT Gateway module from a particular producer necessitates several adaptable and interconnected IoT solutions. An illustrative simulation topology for the IoT Gateway scenario is provided below. In this specific scenario, the power requirements for the household lamp are fulfilled by a battery charged via a solar panel.

```
var smkSensor = A0;
var grgDoor = 5;
var window = 4;
var door = 3;
var houseFan = 2;
function setup() {
  pinMode(grgDoor, OUTPUT);
  pinMode(door, OUTPUT);
  pinMode(window, OUTPUT);
  pinMode(houseFan, OUTPUT);
}
function loop() {
  var newVal = analogRead(smkSensor);
  newVal = newVal /10;
  if (newVal > 10) {
    customWrite(grgDoor, 1);
    customWrite(door, 1);
    customWrite(window, 1);
    customWrite(houseFan, 2);
  } else {
    if (newVal < 2) {
      customWrite(grgDoor, 0);
      customWrite(door, 0);
      customWrite(window, 0);
      customWrite(houseFan, 0);
    }
  }
  Serial.println("Smoke Level : " + newVal);
}
```

Figure 24: JavaScript Codes in The MCU Device

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CONNECTIONS WITH ARDUINO UNO

In this phase, the linking of various components with the Arduino is executed. The Arduino's programming aligned with the hardware connections established with it. Specifically, connection of the Arduino with the Bluetooth module HC-06 and the ULN2003 is required. The ULN2003 interfaces with the relays, which in turn regulate AC loads based on user instructions received via the Smartphone. Commands transmitted from the smartphone prompt the Arduino Uno to relay input signals to the ULN2003 (Darlington pair), thus initiating or halting relay operations.

Programming the Arduino UNO

Programming the Arduino Microcontroller using the Arduino IDE 2.0.4, The open-source Arduino Software (IDE) makes it easy to write code and upload it to the board. This software can be used with any Arduino board. Programming Arduino is easy, the paper used C programming language to achieve this, and one advantage is that when you program and upload to the Arduino microcontroller it is stored and keeps running the commands infinitely.

Developing the Android App

The Control Android App is developed using Java programming language with MIT App inventor. The App connects Arduino via Bluetooth and sends a command signal that the microcontroller then executes.

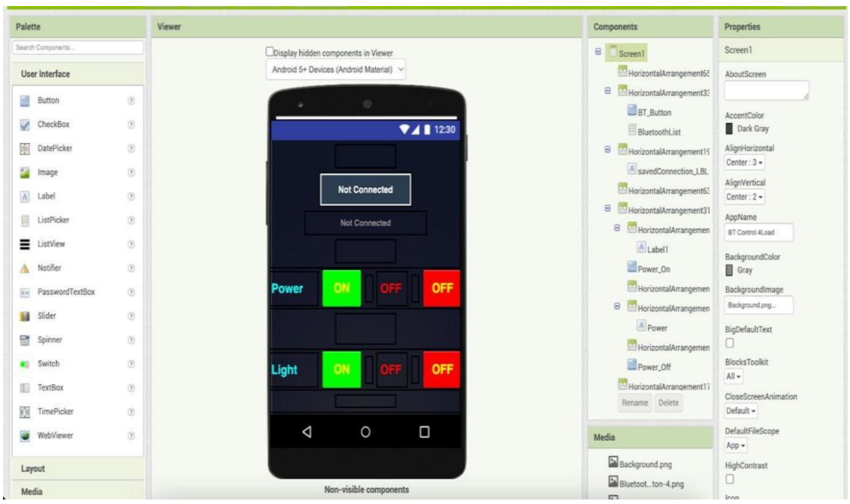

Figure 26: Android Development IDE

Bluetooth Connection

The HC-06 Bluetooth module facilitates serial and UART communication between your Arduino Uno or any compatible microcontroller and a PC or Smartphone equipped with Bluetooth capability. Establishing a connection between the Arduino Uno and the HC-06 Bluetooth module opens up a plethora of applications, including remotely controlling home lighting, operating an RC car, or managing a robot through a mobile application. Specifically,

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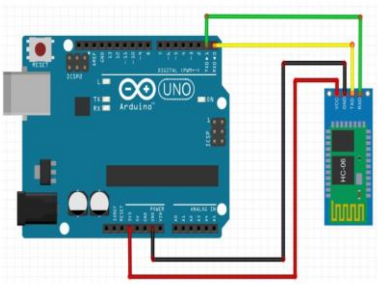
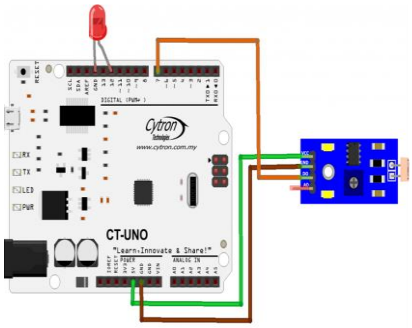
Arduino pins 0 and 1 are designated for Universal Asynchronous Receiver/Transmitter (UART), which manages communication with attached serial devices.

Table 3: Bluetooth Module and Arduino Connections

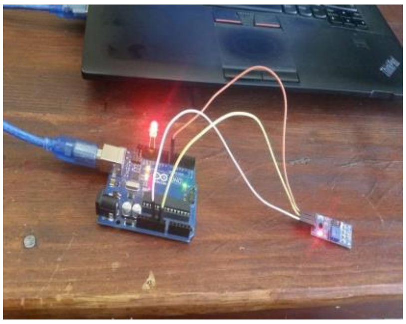
BLUETOOTH MODULE HC-06	ARDUINO UNO R3
TX	RX (pin 0)
RX	TX (pin 1)
VCC	3.3 volt supply from Arduino
GND	Arduino ground

To establish communication between the Arduino and the PC via a USB cable utilising a serial connection, a library named "SoftwareSerial.h" was required. This library grants you the capability to configure serial communication on virtually any digital pin of the Arduino Uno.





Figures 27 and 28: The Arduino Uno Connected to Bluetooth Module (HC-06) & Photosensitive Sensor Module Connection respectively.



Figures 29 and 30: Showing the Photosensitive Sensor Module Connection – Day Ligh ON, Photosensitive Sensor Module Connection – Day Light OFF respectively.

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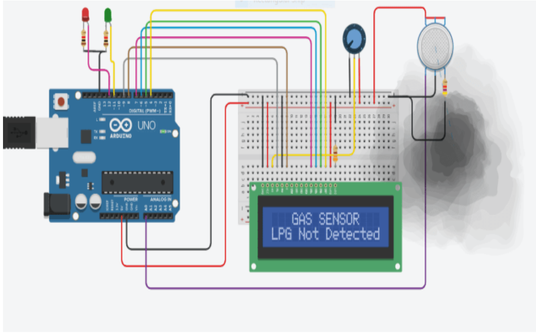
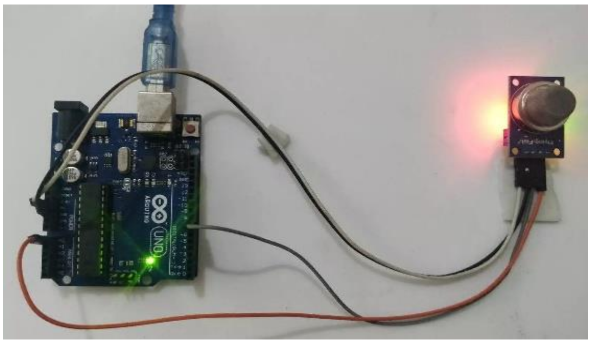
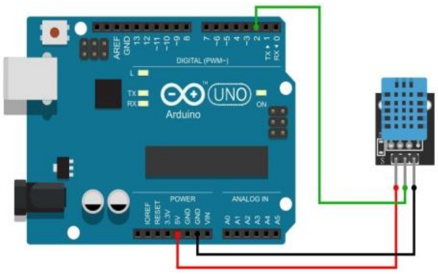
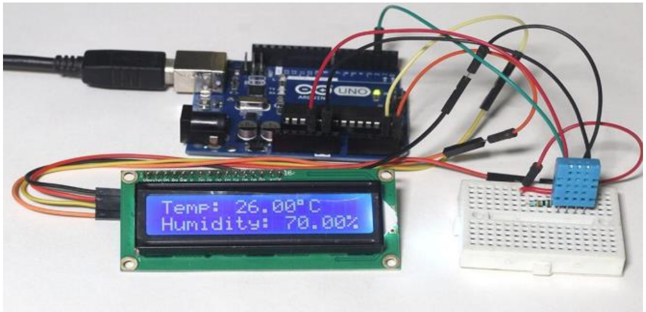




Figures 31 and 32: MQ-2 Smoke, Gas Sensor Detector Connection – Active & MQ-2 Smoke, Gas Sensor Detector Connection respectively.





Figures 33 and 34: DHT11 Sensor Module Connection & DHT11 Sensor Module Connection – Active respectively.

CONNECTING ARDUINO WITH HOME APPLIANCES – THE PROCESS

Step 1:

To connect the software and the hardware to enable communication and thus home automation links the +5V and GND pins of the Arduino to the bus strips on the breadboard, following the configuration depicted in the circuit diagram above. Subsequently, supply power to the HC-06 module by connecting its 5V and GND pins to the breadboard's bus strips.

Step 2:

The HC-06 operates on 5VDC and incorporates an integrated voltage regulator responsible for producing a 3.3V power source to energise the transceiver. Consequently, the TXD/RXD pins function solely at 3.3V. Establish a connection between the TXD pin on the HC-06 module and the RXD pin (Pin 0) on the Arduino. This linkage facilitates data transmission from the HC-06 to the Arduino.

Step 3:

Currently, it proceeds to link the relay module's 5V and GND pins to the bus terminals on the breadboard. Following this, establish a connection between the IN1 pin on the relay module and PIN 4 on the Arduino. Utilising a multi-channel module (such as 2, 4, or 8 channels), you have the flexibility to link IN2 and IN3. IN(n) with various digital pins on the Arduino. Repeat

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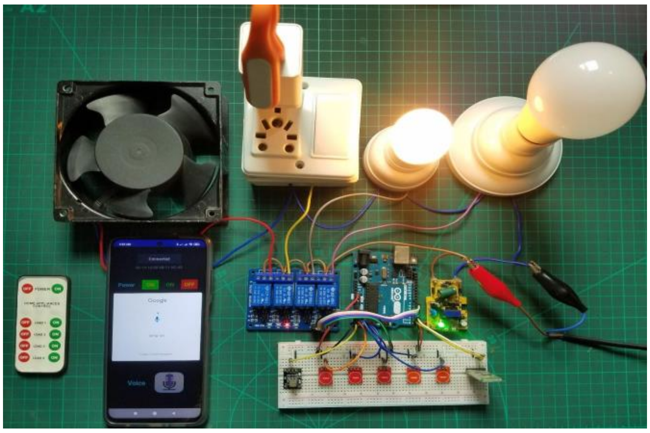
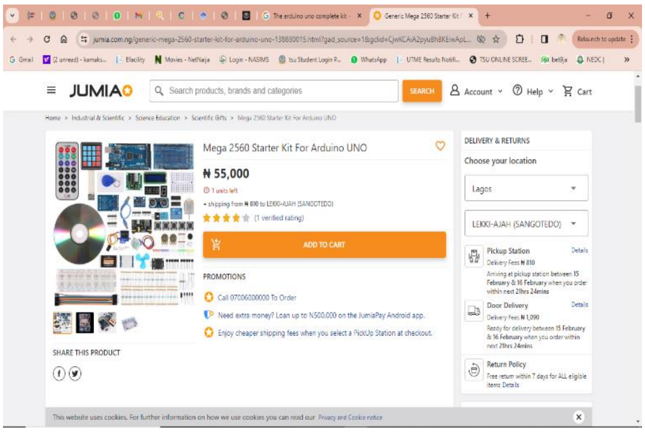
the outlined procedure for configuring the remaining pins accordingly. Subsequently, the AC load must be connected to the relay module. Upon inspecting the terminal block on the relay module, you'll discern three terminals designated for this purpose.





Figures 35 and 36: Arduino UNO integrated with Android (Control), Relays, Loads (Switches), Fans, Bluetooth HC-06, MQ-2 and Photosensitive Sensor & Arduino UNO M-2560 Starter Kit Price (Jumia, 2024)

NOTE: With the setup outlined above, you have the capability to transform any device into a smart device, enabling remote control from your smartphone from virtually anywhere.

Finally, Step 4:

When the relay is inactive, the COM terminal establishes a connection with the NC (Normally Closed) terminal. Consequently, if you attach the bulb to the NC terminal, it illuminates even without energizing the relay. However, this setup does not align with our objective. Our intention is to illuminate the bulb solely upon receiving a signal from the smartphone. Hence, the paper opts to connect the load to the NO (Normally Open) terminal. This arrangement ensures that when the relay is activated by the Arduino, the contact transitions from the NC terminal to the NO terminal, thereby closing the circuit and illuminating the bulb.

CONCLUSION

While the end results proved highly effective in achieving the set objectives, it's crucial to note that these outcomes represent basic prototypes. Substantial further development would be necessary to transform them into market-ready products. Key areas requiring improvement include device size, cost, power sources, and communication range. All tasks within this paper were executed successfully. The paper managed to meet the developed system objectives as outlined below:

i. Constructed a wireless home automation system controlled by a smartphone specifically an android device

ii. Designed and implemented an efficient and cost-effective home automation system.

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iii. Simulated a user-friendly and secure system that controls home appliances especially targeted to help the old and handicapped/disabled.

Nevertheless, constraints in terms of time and expenses are evident; however, it is anticipated that these limitations serve as a foundation for the advancement of other cutting-edge AI systems and concepts. Nearly all scientific and emerging technologies come with both advantages and disadvantages, but this shouldn't deter us from embracing technology. endeavours driven by technology, such as this one, should motivate us to strive for improvement in service to our society. By focusing on maximizing the benefits, it becomes apparent that smart technology is indeed a boon to individuals and society as a whole. It is advisable to steer clear of the negative aspects of technology and instead, embrace the positive.

This paper employs IoT technology to replicate the automation of household appliances while also deliberating on its merits and demerits. Although a wireless-enabled home automation kit offers versatility and affordability, its connectivity is limited to Bluetooth within a constrained range. Utilizing Arduino UNO modules, a mechanization solution was devised to establish a wireless network enabling remote monitoring of household appliances. Moreover, a smartphone-centric home automation framework was explored, empowering users to control and supervise home appliances via a simulated interface on their smartphones. The Internet of Things serves as the driving force behind home automation in this paper.

REFERENCES

[1] Alkar, A. Z., and Buhur, U. (2015). An Internet Based Wireless Home Automation System for Multifunctional Devices. IEEE Consumer Electronics, 51(4), 1169-1174. Retrieved from http://www.thaieei.com/embedded/pdf/Automation/

[2] Arun, F. G., Ashok, M., Cyril, S. A. K., Kamaleshwarran, A. P., and Kumaravel, B., (2021). “Pulsed Electric Field based Vegetable Fresher”, Annals of RSCB, pp.9918–9926.

[3] Arun, F. G., Chandru, L., Aruna, K. B., Nithesh, K. R., and Narendran, S., (2021). “Charging Time Controller using Arduino”, Annals of RSCB, pp. 9886–9894.

[4] Arun, F. G., Dharani, S. K., Manikandan, P., Monica, R. J., and Vaan, S. K., (2018). “IOT Based Accident Identification and Alerting System”, International Journal of Pure and Applied Mathematics, 118, (20), 547-551.

[5] Arun, F. G., K. A., Lalithambiga M., Niveka, S., and Nivedha, E., (2021). “Density based Traffic Light Control Using Retransmitted and Receiver”, Annals of RSCB, pp.9895–9901.

[6] Arun, F. G., Karthigaikumar P., and Arun K. G. (2020) Face Recognition System for Visually Impaired People. Journal of Critical Reviews, 7 (17), 2760-2764. doi:10.31838/jcr.07.17.345

[7] Arun, F. G., Lexmitha, S., Aruna, D. N., and Swathika C. K., (2021). “Embedded System based Smart Automation for Elderly and Disabled People”, Annals of RSCB, pp. 9909–9917.

[8] Arun, F. G., Manikandan, S., Sundar, V., and Gowtham, E., (2021). “Home Automation Using IoT”, Annals of RSCB, pp. 9902–9908.

[9] Ciubotaru-Petrescu, B., Chiciudean, D., Cioarga, R., and Stanescu, D. (2016). Wireless Solutions for Telemetry in Civil

Article DOI: 10.52589/AJSTE-K3MYSZ7C
DOI URL: https://doi.org/10.52589/AJSTE-K3MYSZ7C

Equipment and Infrastructure Monitoring. 3rd Romanian-Hungarian Joint Symposium on Applied Computational Intelligence (SACI). Retrieved from http://www.bmf.hu/conferences/

[10] Francis, A., Arulselvan, M., Elangkumaran, P., Keerthivarman, S. and Kumar, J., (2019). Object detection using ultrasonic sensor. International Journal of Innovative Technology and Exploring Engineering. 8. 207-209.

[11] Francis, A., Wilfred, M.W. and Sekar, R. (2019). Health monitoring with alcohol detection and ignition control system using IoT. International Journal of Innovative Technology and Exploring Engineering. 8. 203-206.

[12] Loup Ventures. (2019). Annual Digital Assistant IQ Test. loupventures.com/annual-digital-assistant-iq-test/

[13] Luo, C. H., Wang, H., Luo, F., Zhang, F., Lin, k., and Xu G., (2021). "G2F: A Secure User Authentication for Rapid Smart Home IoT Management," IEEE Internet of Things Journal, XX (XX), 1–12.

[14] Manikandan, S., Karthik K., and Arun F. G., (2015). "Vector Monitoring Concurrent BIST Architecture using
Modified SRAM Cells", International journal of science and advance research in technology, 1 (9), 14-17.

[15] Ramlee, R. A., Othman, M. A., Leong, M. H., Ismail, M. M., and Ranjit, S. S. S. (2013)."Smart home device using
android framework," Information and Communication Technology, 2013 International Conference of, Bandung.

[16] Vignesh, M., and Kavin T, P. (2020). Accident Detection and Alerting System Using GPS & GSM. International
Journal of Advanced Science and Technology, 29 (3), 3598 - 3601.Retrieved from http://sersc.org/journals/index.php/IJAST/article/view/5037

Article DOI: 10.52589/AJSTE-K3MYSZ7C
DOI URL: https://doi.org/10.52589/AJSTE-K3MYSZ7C