

Lora Based Intelligent Home Automation System

Bababe Adam B., Ashish Kumar J., Rajiv Kumar

Abstract: *The home and Society are surrounded by "things" which are connected to each other, either directly or indirectly via the internet of things. To have access to controlling these devices remotely with precision within the network when required is a key factor in the process of home automation. There are numerous aspects in this automation that needs to be developed so as to enhance it. This research gives a solution to having a precise and direct control and automatic detection of current state of devices with the use of android application. It also gives a practical implementation of home automation using LoRa in comparison to other technologies.*

Keywords: *Home Automation; Internet of Things; LoRa; Android; Smart*

I. INTRODUCTION

Internet of Things (IoT) may be very difficult to explicitly define but it can be described as a system of closely or loosely computing devices, analogous/mechanical and digital machines, animals or people that have been uniquely tagged with identifiers. These things also have some ability to transfer data/information over a network without the interference of either human or computers. Entities that can be termed as thing in the internet of things range from specific capabilities of being assigned some IP address and also have the ability to achieve data transfer over a network. The idea of IoT was given birth to from the confluence of technologies that had been in existence for decades. These technologies include; electromechanical systems, the internet and wireless technologies. To use the idea of IoT to develop home automation has become a thing to desire and have implemented. As with every technology, home automation is in its developmental stages and as such requires a lot of researches and inputs from industries, academia and professionals alike.

II. LITERATURE SURVEY

A. Internet of Things

Internet of Things (IoT) is a technology that connects all things and the internet in smart spaces by the implementation of intelligence with sensing devices. This technology has been applied to different fields in most walks of life like industries, health, home etc [1]. It was also defined as a network of physical objects that have been incorporated with sensors, RFIDs, triggers, firmware and internet capability to enable them to interact with operators, and other connected devices to reach common goals.

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It has been a hotspot in both academia and industry since it was proposed by Kevin Ashton in 1999. As a coinage that is envisioned to involve all things in the world, IoT can never be an isolated kingdom. It has extensible and compatible features, and is always ready to absorb advantages in every aspect of information domains. Its positive significance will never be appreciated until there is a complete formation of cyberspace, where human beings, computers, and smart objects are interconnected. This process can be regarded as the integration of IoT and existing network systems including cloud computing, the Internet, smart phones, and social and industrial networks [2].

B. Home Automation

Home automation happen to be a great idea in the field of computing, this becomes a greatly important and interesting when the concept of internet of things is used to achieve this implementation. Home automation aims to provide improved, convenient, comfortable, energy efficient and security to the residents through the automation of home appliances, household activities [3]. Particularly, home automation can provide increased quality-of-life for persons who under normal circumstance would require close care or institutional care, such as the elderly or disabled. As the technology of Internet of Things (IoTs) matures, home automation has been accelerating its penetration into average households in recent years. Lured by this huge market, many companies have made significant investment in home automation products. Google, Samsung, Apple, for example, have unveiled their respective home automation platforms or products [4]. One of the main features of home automation is the concept of automation. This happens when devices on a network can be programmed and controlled according to specified scheduled events. Commands being programmed that require timed/scheduled triggering or those are not scheduled but happen on ad-hoc basis. In the home, automation may range from the turning of lights, opening/closing of doors, air conditioner regulation, coffee maker control, sprinkler system monitoring and a host of other household chores. The other concept involved in the features of home automation is remote access and monitoring, to have some degree of monitoring has been in existence with limited possibilities, but to be fully in control and truly have an automated environment and controlled remotely came into prominence with the emergence of smart-phones and smart devices [5]. If done correctly, an ideal home automation system can make use of any Internet-ready device to access and control the system and all devices within the network. Security status, current temperature of the home and other factors may be controlled with this concept. Real life feel of the system and the environment is demystified with the inclusion of real-time audio-visual devices. Recently, wireless systems like Zigbee, Wi-Fi, LoRa and Bluetooth have become common in home networking [6].

Table 1 below gives a comparison of the various technologies used for this purpose;

Table 1: Comparative Analysis of Technologies used in Home Automation

Ref. Id.	System	Technology Used	Merits	Demerits
[7]	RF Module based home automation	RF Module which implements through FPGA board	Low cost Low power usage Less complexity	Design process is difficult as it involve cryptography
[8]	Bluetooth based home automation using FPGA	HC-05 is the Bluetooth module used to control appliances that are connected to FPGA	Alert system is quick in case of emergency	Range is not wide May function improperly in some cases
[9]	Wi-Fi based home automation using Arduino Microcontroller	Wireless LAN and Wi-Fi shield	Low cost Secure Remotely controlled	Susceptible to interference
[10]	Cloud based home automation using Zigbee	Zigbee Wireless network	Power saving Convenient secure	Low interoperability
[11]	GSM based home automation using Arduino	SMS	Simplicity	Expensive insecure
[12]	Home Automation Control and Monitoring System Using BLE Device	BLE	Low cost Low power	Limited number of devices Short range
[13]	LoRa for the Internet of things	LoRa shield and module	Low cost Low power Long range	Low data rate

C. Advantages of Home Automation

In home automation systems, the use of wireless technologies gives several advantages which give it an upper hand compared to a wired network.

- **Reduced installation cost:** In this use of implementation, installation costs are significantly reduced because cables are not required. Solutions that require cabling tend to be expensive due to the fact that cables, cable connectors, cable laying accessories and others including labour must be paid to achieve this.

- **System scalability and easy extension:** Creating a wireless network is of great advantage when expansion is required; the only task is to give room for more nodes. This makes deployment of wireless technology for home automation a one-time investment.

- **Aesthetical benefits:** Apart from ranging wide coverage, automation has the beauty of having things in the network working round the environment without external forces.

- **Integration of mobile devices:** Automation system becomes possible everywhere and at any time, as a device's exact physical location is no longer crucial for a connection.

D. Disadvantages of Home Automation

Technologies are developed to improve and enhance lives and the environment; this does not mean that any technology developed does not have some draw backs. Home automation is not left out in this phenomenon, some disadvantages or draw backs related to it are;

- **Facilities and installation costs:** Home automation is dependent on the cost of equipments you intend to install and how you want to deploy it. Complication level determines how high or low the cost of the system installation will be. With the gradual growth in the number of home automated devices in existence, cost of installation was supposed to be reduced, yet it has not reduced because of the unpopularity of the home automated devices. Currently, the technologies in use are unable to cover the entire desired home automation plan.

- **System crashes due to any damage in the interconnection:** Damages are bound to occur in a copper of fibre cable connected home network. This is not the case with radio signals or the other wireless signals. The major problem with these types of connection is the problem of signal receiving.

- **Human errors:** Improper handling of automation kit safely to perform basic operations, human errors may occur. Destructions of devices and other equipments due to this error may lead huge system failure.

- **Reliability:** In very exceptional cases, the reliability of devices deployed for home automation tends to decreases. Degree of advancement and type of technology used determines the reliability of the system. At this stage of smart home, this cannot be guaranteed [14].

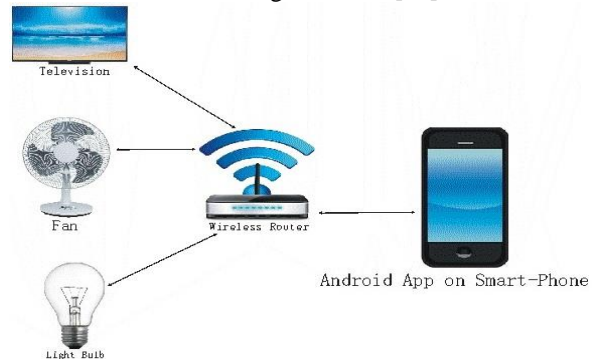


Fig. 1. Basic Home Automation

E. Components of Home Automation

As any given system, home automation system consists of different components. A basic home automation has three main components, a server, hardware interface module, and a software package. The combination of these components has capabilities to control the following in home and monitor some of the following;

- Current Temperature and estimated humidity level
- Motion detection
- Fire/smoke detection
- Status of Doors
- Light level
- Monitoring of life Video



F. Android Operating System

Android operating system is one based on Linux kernel developed by Google. This operating system is primarily designed for use on smart-phones and tablets. Android is an open source as thus has become one of the fastest growing operating systems. This open nature it has made it to become the favourite for many consumers and developers. Software developers have the ability to easily modify and increase desired feature in it to meet requirements of the mobile technology. Billions of Android users download applications and games from Google Play store on monthly basis. With the advent of this Powerful development framework, now users as well software developers can easily create their own applications for wide range of services and devices [15]. Android provides Android Software development kit (SDK) for user to develop well suited applications that serves their purpose. Java programming Language is used for the application development.

G. Long Range (LoRa)

LoRa is a new energy-efficient long-range wireless technology that has been developed to enable low data rate communications over long distances by sensors and other battery-powered devices. Using LoRa and the associated LoRaWAN network protocol it is possible to securely connect millions of devices to the cloud in secure local, regional, national or worldwide networks. LoRa is quickly becoming the leading enabler of the Internet of Things.

Conventional wireless data communication technologies like Wi-Fi or 4G were developed for the high speed transfer of large amounts of data to and from the Internet. LoRa is different and has been designed to maximise energy efficiency in applications that only need to securely exchange small amounts of data with the Cloud. LoRa-enabled devices conserve energy by powering down between short data transmissions, which are sent and received at pre-set times, or in response to external events. This highly efficient method of operation enables a typical LoRa wireless module to transmit and receive data for 10 years using two penlight batteries. The term LoRa stands for Long Range communication. Even with highly efficient ultra-low power consumption a LoRa radio module can transmit data over 20km (line of sight) in a rural environment. In dense urban environments LoRa-enabled devices can send data over 3-5km, (depending on the antenna size and elevation). Unlike some other technologies LoRa radio signals can penetrate deep into buildings. LoRa facilitates two-way communication between a server and a connected device. Security is provided through the use of spread spectrum technology supported by a unique Network key (EU164), a unique Application key (EU164) and a Device specific key (EU128). Further security is provided to prevent spoofing, flooding and man-in-the-middle network attacks [16].

H. Wi-Fi Technology

Wi-Fi is a technology that uses radio waves to provide network connectivity. it provides wireless connectivity to devices by emitting frequencies between 2.4GHz - 5GHz, based on amount of data available on the network. The Wi-

Fi Alliance defines Wi-Fi as any "wireless local area network" WLAN product based on the Institute of Electrical and Electronics Engineers' IEEE 802.11 standards. Devices which use this technology may include but not limited to personal computers, game consoles, smart-phones, digital cameras, tablet computers, digital audio players and modern printers. Wi-Fi compatible devices can connect to the Internet via a WLAN network and a wireless access point. Such an access point (or hotspot) usually has a range of about 20 meters when indoors and much more when placed outdoors. It has coverage of hotspots from single room with walls that blocks radio waves to large areas covered by square kilometres which can be implemented by placing multiple overlapping access points [17]. Currently existing home automation systems are mostly IR sensor based [18], these IR based sensor are usually difficult to directly connect to because of the random nature of usage involved. There is the need to have a standards used in the control of these home appliances with precision [1]. There is also a problem of having to manually identify the current state of devices within the network, there will be a need to implement a mechanism for auto discovery of devices to help increase reliability and reduce cost in term of energy and finances in the home automation process [1]. The main objectives of this work include;

1. To design and implement a home automation system using IoT that is capable of precisely controlling and automating of home appliances through an android application interface. The proposed system uses LoRa technology to interconnect home devices.
2. To develop an auto-discovery functionality of current state of devices. Devices may be in any of several states (on, off, open, close, high, low, full, empty etc) depending on such devices, it is important to automatically detect the current state before a trigger or actuator is used in the system.

III. METHODOLOGY

The Hardware interface module consists of Arduino Uno microprocessor, LoRa module and relays. The central device is the microprocessor that connects to the LoRa module and receives orders to monitor and control the appliances. The communication between the application and microprocessor is handled by the server, thus managing the users and the appliances. The software communication module uses an Android application as the frontend, which serves as an interface to the user to communicate with the microprocessor. It presents a list of devices with which the user can interact. The system offers switching functionalities to control the appliances connected to the system, which includes Lights, Fans, Air-conditioners and various other appliances connected to the system. Arduino Board is not capable of withstanding high Voltages which is usually 230V. Thus, Relays are used to convert this high voltage to low voltage i.e. less than 5V. The relay switches have capability to carry a maximum load of 10A at 240V.



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To enable connectivity with the microcontroller, LoRa module is used. It provides connectivity to the server for access and control from the Android Application effectively and efficiently. The Android application is a user friendly interface, which enables the user to view the status of applications at home and control it as per his/her requirement.

Step 1: In order to establish connection between the client and the server the LoRa option on the end user device is enabled.

Step 2: It is connected to the LoRa module of the system.

Step 3: Each electronic/electrical appliance in the system is connected to the digital pins on the Arduino Uno Board.

Step 4: A Relay is used for connecting each device to the Arduino, which helps in converting high Voltage supply to low voltage.

Step 5: A C-program is loaded on to the microprocessor chip on the Arduino Uno Board which specifies what action is to be performed on receiving particular inputs.

Step 6: An Android Application has been developed which enables the end user to monitor and control the appliances from any remote location.

Step 7: Socket Programming has been used to achieve client-server communication.

Step 8: Successful controlling and monitoring of appliances.

This setup is fully illustrated as shown in Fig. 2.

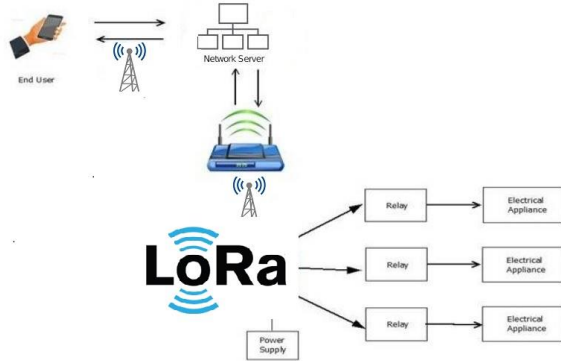


Fig. 2: Proposed Home Automation System

I. Facilities required for proposed model

1) Hardware requirements

To implement the proposed automation system, the following hardware components shall be required; Arduino Microcontroller, LCD display, A to D converter, Temperature sensors, Relay, Resistors, Capacitors, Diodes, 230/12V Transformer, 7805 Voltage Regulator, Transistors, LoRa module.

2) Software requirements

Keil Compiler: Keil an ARM Company makes C compilers, macro assemblers, real-time kernels, debuggers, simulators, integrated environments, evaluation boards, and emulators for RM7, ARM9, Cortex-M3, XC16x, C16x, ST10, 251, and 8051 MCU families.

- Embedded C Compiler: Compilers are programs used to convert a High Level Language to object code. Desktop compilers produce an output object code for the underlying microprocessor, but not for other microprocessors.

- Android Software Development Kit: Android software development kit is a set of comprehensive of

development tools include a debugger, libraries, a handset emulator based on QEMU, documentation, sample code, and tutorials. The platforms supported for this development are computers running Linux Operating system and some versions of Windows operating system.

IV. RESULTS AND DISCUSSION

Based on the design running of the model using LoRa, Android application and static IP addresses configured, the precision of the home automation system is fairly appreciable and more to the point. It can be seen from Fig. 3.

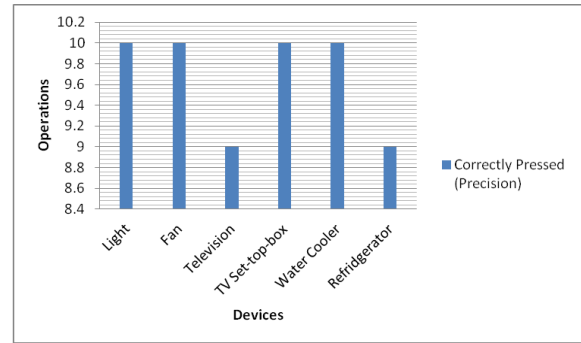


Fig. 3 Devices versus Operation graph

From the figure above, it would be seen that six (6) home devices used for the study were precisely controlled, in a total of ten (10) operations each, about four (4) of them were correctly controlled all the times and the remaining four were correctly controlled nine (9) times each. This shows that the system is efficiently satisfying the purpose intended.

V. CONCLUSION

Technologies deployed for home automation that are available in the market are based on platforms which help to connect devices or things around the home, the key point is to make the home intelligent or smart with ease. To achieve this with precision by the use of static IP addresses and having the ability to detect the current state of devices by use of state function was achieved in this paper. In conclusion, it has been seen that home automation using internet of things over LoRa technology with the help of Android application is both user friendly and cost effective. The success rate of this model is about 95% according to results obtained from the analysis. Further work in this work shall cover aspects of cost reduction in implementation and further reduction in the power consumption of such models.

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