

# Smart Air Conditioner using Internet of Things

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## Abstract

The local remote control is the traditional mechanism in which the end user controls the air conditioner. In the absence of this mechanism, the user loses the control. This thesis aimed to design and implement a smart air conditioner using Internet of Things (IoT) technology. Recent literatures were reviewed to select the most optimal platform to design and implement the project. The design of the project was then developed based on the selected platform.

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## *Index terms—*

## 1 Smart Air Conditioner using Internet of Things

Khaloud Bati AL-Sa'idi ? & Dr. Vladimir Dyo ? Abstract-The local remote control is the traditional mechanism in which the end user controls the air conditioner. In the absence of this mechanism, the user loses the control. This thesis aimed to design and implement a smart air conditioner using Internet of Things (IoT) technology. Recent literatures were reviewed to select the most optimal platform to design and implement the project. The design of the project was then developed based on the selected platform. The project was then implemented and tested successfully. In order to validate the project, a questionnaire was carried out by potential users who tested the product on their SANYO air conditioner. All potential users were able to control their air conditioner remotely over the internet from anywhere. The smart air conditioner has absolutely no inference against real remote control. The product is cost effective, energy efficient and achieves the required automation functionality.

## 2 I.

Introduction s it is known, the usual and traditional mechanism in which the end user controls the air conditioner is through local remote control. However, what if the local remote control is lost, broken, out of batteries or no longer available due to whatever faulty?

On the other hand, what if the air conditioner is forgotten on due to human nature and no one is available to turn it off?

How about controlling the temperature degree of your air conditioner while you are actually away?

How about having a smart air conditioner that would be able to turn off by itself when people are not present and save energy?

Reaching this point, Automation feature seems the best logical solution to handle and control the air conditioner remotely.

Nowadays, Internet of Things (IoT); an emerging technology has risen in the digital realm. The original idea of Internet of Things was proposed at the end of 1990's. IoT is much more related to the wireless sensors networks, mobile communications networks and Internet. IoT can be defined as a network that connects every existing physical object in the world to a unique address in order to provide quick and smart services. In contrast to traditional Internet which interconnects intelligent physical objects only, IoT interconnects both intelligent and non intelligent physical objects due to the availability of object sensing layer (Ma, 2011).

Hence, with Internet of Things, you may control everything using internet service. More specifically, through Internet of Things technology, you will be able to remotely control your air conditioner which will be connected to the internet from anywhere.

Internet of Things technology uses cost effective, powerful and small size device that is considered to be a small size single board computer called Raspberry Pi. Raspberry Pi was developed by Raspberry Pi Foundation.

### 3 LITERATURE REVIEW

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46 There are four different types of Raspberry Pi such as: Original Raspberry Pi, Raspberry Pi, Raspberry Pi 2  
47 and Raspberry Pi 3. The four different types come with both Model A and Model B flavors. Different platforms  
48 can be used as an Operating System for the Raspberry Pi such as: RISC OS, Arch Linux, Pidora, Raspbian and  
49 Microsoft Windows 10 IoT core (Harrington, 2015).

50 The aim of this project is to design and implement a smart air conditioner using Internet of Things technology  
51 using Raspberry Pi 3 Model B device.

52 The aim of this project is accomplished through fulfilling pre-defined objectives. Starting with reviewing related  
53 home automation system literatures. Moving to selecting the most suitable platform (Raspbian: the most popular  
54 platform used with Raspberry Pi or Windows 10 IoT core: the new platform developed by Microsoft) to design  
55 and implement the smart air conditioner. Testing, validating and exploring the gained features of the product  
56 are the final step towards accomplishing the project aim.

57 The features of the designed smart air conditioner were decided through testing the implemented product by  
58 potential users. The smart air conditioner has absolutely no inference against real remote control. The product  
59 is cost effective, energy efficient and achieves automation functionality indeed.

60 Each implemented project must involve intellectual challenges.

61 Apparently, there are implemented air conditioner projects using Internet of Things raspberry Pi with different  
62 web and mobile enabled applications. However, in this project the web application is developed using PHP web  
63 language and MySQL database engine which are not used by any of the developed projects.

64 Internet of Things means any physical object is connected to the internet. In this system, a smart air  
65 conditioner which can be controlled remotely through a web application is to be implemented. However, in  
66 order to control the air conditioner remotely, it must be connected to the internet in the first place. Obviously,  
67 the air conditioner does not have any internet connection port. Hence, it will be connected to the raspberry pi 3  
68 that has the required internet connection A port. The connection between the air conditioner and the raspberry  
69 pi 3 is through the Infra-Red (IR) transmitter which is a Lite Emitting Diode (LED) emitting Infra-Red lights  
70 (connected to the raspberry pi 3) and Infra-Red (IR) receiver. Then, the internet connection port in raspberry  
71 pi 3 will be connected to Wi-Fi hot spot in order to get internet service. On the other hand, any physical device  
72 such as: a desktop, a laptop, a PAD and a smart phone which has a web browser in order to use the implemented  
73 web application is connected to the internet from anywhere to control the air conditioner remotely. Furthermore,  
74 the implemented air conditioner would be able to turn off by itself when people are not present.

75 The following figure illustrates the above mentioned project specifications.

### 3 Literature Review

77 Home automation systems have been a successful revolution in the technology world. Extensive researches were  
78 conducted on home automation systems. Indeed, home automation systems still receive an inordinate attention  
79 from academic organizations and institutions.

80 Different technologies have been employed to build home automation systems, Al-Ali & Al-Rousan (2004)  
81 built a java-based home automation system where all home automated appliances were connected physically to  
82 an embedded board with integration to a Personal Computer acts as a web server which provided a remote access  
83 to the built system.

84 Java-based home automation system provides a secure solution due to the built-in security feature handed  
85 over by java technology. However, the system is not cost effective due to the need of high quality specifications of  
86 the Personal Computer as well as expensive installed wired environment. Furthermore, since the system depends  
87 mainly on wired communication, installation's intrusiveness is increased. Srisanthan et al. (2002) developed a  
88 Bluetooth based home automation system where each home physical appliance is connected to a local Bluetooth  
89 sub controller through wired connections. Each appliance communicates with the local Bluetooth sub controller  
90 connected to and then all local Bluetooth sub controllers communicate with a primary controller through wireless  
91 connection.

92 In contrast to Java-based home automation system, Bluetooth based home automation system architecture  
93 reduces intrusiveness of wired installation due to the use of wireless technology. Nevertheless, some intrusiveness  
94 is still there due to the wired communication between home appliances and Bluetooth sub controllers. Moreover,  
95 this system connects one Bluetooth sub controller to many home physical appliances due to the cost of Bluetooth  
96 technology where it is appropriate to have a dedicated Bluetooth sub controller for each appliance. Never forget  
97 to mention that the use of one Bluetooth sub controller shared between many home appliances actually causes  
98 access delay. Zhu et al. (2010) proposed a Voice Control System for Zig Bee-based Home Automation system.  
99 Automatic speech recognition module is used to translate voice commands and send them to the actuator of  
100 the designed system via ZigBee network. Each automated home appliance is connected to a dedicated ZigBee  
101 module in order to operate and control it remotely.

102 Similar to Java-based home automation system, developing a Voice Control System for ZigBee based Home  
103 Automation system is not cost effective due to the expense of ZigBee module; hence the system is becoming  
104 uneconomical as the number of physical home appliances to be automated is enlarged. Furthermore, the speech  
105 recognition system must have a module which unfortunately causes errors due to the noise.

106 imperfections and limitations such as the cost, access delay, wired installation intrusiveness and power  
107 consumption.

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108 In this project, I selected different and innovative but existing technology which is Internet of Things (IoT). The  
109 reason behind using this technology in this project can be justified from my following findings on IoT technology.

110 Internet of Things is considered to be the revolutionary technology in the future of the internet (Gubbi et al.,  
111 2013). Ma (2011) declared that the original idea of Internet of Things was proposed at the end of 1990's through  
112 MIT Auto-ID Labs. IoT is much more related to the wireless sensors networks, mobile communications networks  
113 and Internet. IoT can be defined as a network that connects every existing physical object in the world to a  
114 unique address in order to provide quick and smart Services (Ma, 2011).

115 IoT is a complicated technology and it consists of four layers; application service layer, information integration  
116 layer, data exchange layer and object sensing layer. Application service layer offers satisfied services to different  
117 users. Information integration layer integrates unclear information into usable knowledge, recombines and cleans  
118 unclear information attained from networks. Data transmission transparency is handled by data exchange layer.  
119 Sensing objects and obtaining data are handled by the forth layer which is object sensing layer. Never forget  
120 to mention that sensing feature is not supported by traditional Internet and accordingly it only interconnects  
121 intelligent physical objects. On the other hand, IoT interconnects both intelligent and non-intelligent physical  
122 objects due to the availability of object sensing layer (Ma, 2011). Table 1 summarizes limitations of different  
123 existing home automation technologies and IoT addressed solutions. ??(2015) used Siri enabled mobile devices  
124 for remotely control home appliances, which are air conditioner unit, television, window blinds and lights using  
125 raspberry pi with Raspbian Operating System. In this system, the home appliances are connected to the raspberry  
126 pi through a relay and a motor driver. Both raspberry pi and Siri enabled mobile device are connected to the  
127 same local network (Celebre et al., 2015).

128 Rieger (2016) used raspberry pi, IR Diode, IR receiver and stepper motor to build a web interface to remotely  
129 control blind opener and air conditioner. The user accessed the web interface which transmits issued commands  
130 to a controller script. This system used raspberry pi with Raspbian Operating System.

131 Ivancreations.com (2016) built a mobile application and used Google voice recognition to remotely control  
132 Daikin air conditioner unit using raspberry pi and LED. In this system, the air conditioner unit is connected  
133 to the raspberry pi through Infra-Red transmitter LED. Both raspberry pi and the application based mobile  
134 are connected to the same local network through home Wi-Fi router (Ivancreations.com, 2016). The system is  
135 implemented using raspberry pi with Raspbian Operating System.

136 Vasanwala (2015) developed Home Automation using Raspberry Pi2 and Windows 10 IoT system. Lights, fans  
137 and wall sockets are connected to an Arduino -Internet of Things microcontroller device -. Each room must have  
138 its own Arduino connected to home appliances in that room, one Passive Infra-Red module, one temperature  
139 sensor that senses human presence and one LDR which detects light intensity. All Arduino microcontrollers are  
140 then connected to the Raspberry Pi through I2C Bus. Basically, Arduino controls all home appliances and reads  
141 data from sensors and periodically sends those collected data to Raspberry Pi. Raspberry Pi sends data collected  
142 from Arduino microcontrollers to a wire frame application. You may control connected home appliances using  
143 wire frame application as well.

144 Low-cost Home Automation with Voice Control system is built by Gillett (2015). The system used Node.js  
145 server to control different existing hardware in a room such as: lights, door and LED Strip using Raspberry  
146 Pi. A web application is built based on voice control in order to control room's hardware remotely. When the  
147 user clicks on microphone button in the application, Raspberry Pi starts recording voice audio. The recorded  
148 audio is then sent to a natural language API called Wit.ai in order to analyze it and extracts the meanings.  
149 The extracted meanings are then sent back to Raspberry Pi in order to perform the action. The system is built  
150 using Raspberry Pi with Microsoft Windows 10 IoT core Operating System Platform. Ganesan (2015) built  
151 WARAN -Home Automation system. WARAN is a modular system stands for Windows IoT, Azure, Raspberry  
152 Pi, Arduino, NRF24L01+ wireless solution. WARAN consists of one Hub acts as a control server and many  
153 modules such as: temperature sensor module and humidity sensor module which are connected to an Arduino.  
154 The basic functionality of the system is that the added modules read data and sends them to the Arduino through  
155 NRF24L01+. Arduino is then sends collected data from the sensors to the control server in Raspberry Pi through  
156 I2C Bus. Collected data from sensors such as: warnings and alerts in any module is also posted in a Windows  
157 phone application.

158 Through reviewing the above existing recent studies and conducted researches on controlling home appliances  
159 remotely, it is obvious that air conditioner appliance is successfully controlled remotely via Raspbian Platform  
160 using Linux Infrared Remote Control (LIRC). LIRC is an open source library that allows a user to record, decode  
161 and send Infra-Red signals of many standard remote controls (Bartelmus, 2016). On the other hand, there isn't  
162 any published system that controlled air conditioner remotely using Microsoft Windows 10 IoT core Platform.  
163 No one till now could implement any home appliance operates using Infra-Red signals using Windows 10 IoT  
164 core because it does not have any Infra-Red library. There were researches which attempted to automate home  
165 air conditioners using Win LIRC but they all failed. Win LIRC is Windows equivalent of LIRC which enables  
166 users receive and transmit Infra-Red signal of standard remote controls ??Baily et al., n.d.).

167 10 IoT core is compatible with different open source languages and works efficiently with Visual Studio platform  
168 as well (Teixeira, 2015).

169 Window 10 IoT core brings all powerful feature of Windows into your devices such as online storage, 410c

(Teixeira , 2015;. Windows 10 IoT core intended to have a low barrier to access; hence making it easy to build professional devices. Windows designed for an easy use with different software packages (Harrington, 2015).

Windows 10 IoT core is an innovative version of Windows 10 and is targeting the small and embedded devices with or without display screens Raspberry Pi 2, Raspberry Pi3, Minnow Board MAX and Dragon Board recommended to start with Raspbian since it is called Raspbian. Raspbian inherits almost all Debian features including above 35,000 free software packages. Beginners with Raspberry Pi are strongly The system architecture includes the infrastructure and network design of the system. The web application will be designed using PHP web language and Raspbian will be the business logic for the design. The system architecture of the system is shown in Figure 3. My SQL server is used as web server to store data for web console and database server will be hosted in LAMP in Raspberry Pi 3. VPN will be used between the LAMP and the Internet for security issue. PHP will be used as the front End and SQL database as the backend of the web application. The user can access the web application by writing the address in the web browser. On the other hand, the air conditioner is connected to the Wi-Fi at the same time. As mentioned earlier, air conditioner does not have an internet connection port. Hence, it will be connected to the raspberry pi 3 that has the required internet connection port. The connection between the air conditioner and the raspberry pi 3 is through the Infra-Red (IR) transmitter which is a Lite Emitting Diode (LED) emitting Infra-Red lights (connected to the raspberry pi 3) and IR receiver. Always remember that the circuit needs resistors in order to control current flow and maintain the raspberry pi from damage. Figure 4 illustrates circuit design used in the project. IR LED is responsible of emitting infra-red signals and IR receiver is responsible of receiving infrared signals and modulating them. Basically this circuit design is going to be used to read SANYO air conditioner remote control and interpret its codes. The Wire Frame Design for the system is shown in Figure2. When the user who has a right access logs in the website, he will be able to see Control AC tab. The Control AC tab includes controlling AC power and the temperature of the air conditioner. serious limitation with Windows 10 IoT core platform in reference to the lack of Infra-Red library. As a result, the most optimal platform to implement the smart air conditioner using Internet of Things is going to be Raspbian platform since it supports LIRC library. Before implementing the project, an overall design is built.

### 196 4 III.

## 197 5 System Design

198 Through reviewing different recent literatures demonstrated in CHAPTER 2, apparently there is a The following  
 199 software packages are needed to implement the smart air conditioner: ./build gpio -vgpio readall sudo service  
 200 apache2 restart sudo leafpad/etc/lirc/hardware.conf 6. Change hardware. conf file exactly as the following file  
 201 ?#####  
 202 /etc/#####  
 203 7.

204 Type the following commands to stop and start lircd service so that the above made changes take effect  
 205 successfully:

206 sudo /etc/init.d/lirc stop sudo /etc/init.d/lirc start Then you will be prompt to enter a name for each button  
 207 you press. Kindly, note that you cannot enter any random names for your recorded keys. LIRC has its own  
 208 buttons' names. In order to check these valid names, type the following command: irrecord -list-namespace  
 209 irsend SEND\_ONCE ir1.conf KEY\_POWER2

210 7. In order to send the recorded signal for increasing the volume of the temperature, type the following  
 211 command:

212 irsend SEND\_ONCE ir1.conf KEY\_UP MySQL database engine is used to create the database.

213 PHP web language is used as connection agent between the web page and the database. ? Note 2: All files  
 214 related to the web application development will be found the following path:

215 /var/www/html USE ac\_control; SELECT \* FROM login 12. Type the following command to quit MySQL  
 216 server: sudo chmod 777 header.php Weaved is a free software to be installed in Raspberry Pi and enables the user  
 217 to connect to this Raspberry Pi and access its hosted web pages over internet from anywhere. In fact, Weaved  
 218 provides Internet of Things (IOT) Kit to be used in Raspberry Pi. Weaved offers many services such as: SSH on  
 219 port 22, Web (HTTP) on port 80, VNC on port 5901 and custom TCP connection (Sangesari, 2015).

220 q) Setting Up Weaved Software in Raspberry Pi 3: ./weaved-nixinstaller\_1.2.13.bin sudo crontab -e1.

221 3. Add the following lines and exit the editor:

222 @reboot sudo /usr/bin/Weavedweb80.sh start & 4. Press ctrl + x to exit the editor and press Y when it  
 223 prompts you to save changes using CTRL + X 5. Reboot your Raspberry Pi 3 in order to take effect of made  
 224 changes using the command:sudo reboot V.

225 Integration and Testing a) Integration Now implementing and configuring each circuit was done successfully.  
 226 The second stage of implementation is integration. Integration means combining all individual circuits in one  
 227 solderless bread board in order to create one complete circuit. The integrated circuit is illustrated in Figure11.

