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Smart Home Design and Implementation using a Cisco Packet Tracer

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Abstract: *Due to the rapid development in communications and information technology changed human being's way of life where safe, economic, modern and comfortable life has become the ideal for every people. Through the Internet of Thing (IoT) technology, we can make our world smarter. The IoT is encompassing smart machines interacting and communicating with other machines, objects, environments and infrastructures. Now, for example after a long and tiring day of work, what is the first place you want to go to after you finish your job? Certainly, your home, where comfort, efficiency, safety and privacy. In recent years, with the massive development of technology, these concepts have become referred to as the smart home. This research aiming to deliver practical IoT simulations, we designed and implemented smart home using one of the most useful visual simulation software Cisco Packet Tracer. Cisco implemented IoT functionalities in the latest versions of the platform, and now it is possible to add all the smart devices, sensors and actuators, also devices which simulate microcontrollers like Arduino or Raspberry Pi to the network. Cisco Packet Tracer also offers the ability to modify the programming of IoT devices to create special functional simulations for IoT using Java, Python or Blocky, or running it on generic programs.*

Keyword: *Internet of Things; IoT; IoE; Smart Home; Home automation; Cisco Packet Tracer; Sensor*

1. INTRODUCTION

1.1 Home Automation Techniques

Smart home technology is a collective term for information and communication technology (ICT). Is often referred to as home automation, or domestics, which literally means home robots (it comes from the Latin word "domus" which meaning house). Automation is one of the fields that aims to achieve ease while increasing efficiency. One smart home automation system is voice command based. The voice regulated house automation software seeks to advance the reasoning for automation in order to achieve the goal of simplicity [1].

A smart home is a dwelling furnisher with smart systems, objects, devices and machines that have the ability to communicate via the Internet, enabling users to automatically monitor, access and control various functions from anywhere in the world. It also has the ability to communicate and interact with each other without the need for human intervention, as it collects and shares the data of the home residents and automates actions such as warning, implementing various functions according to the conditions previously prepared by the homeowners.

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1.2 Overview of Internet of Things

The Internet of Things (IoT) is a fast-growing network and progress in it has created a new dimension in the world of information and communication technologies. It enables the human to control things smoothly and effectively, either from near or from a distance.

The IoT represents anything that has an IP address in which it can communicate over the network; any physical object can be converted into an IoT device connected to the internet, including living organisms such as humans and animals, by adding sensors or actuators. For example, a person with wearable health monitors, Fitbit for cows, various household items, driverless cars, shipping containers and logistics tracking etc. The IoT device can be as light as a children's toy or as serious as an airplane. One thing itself may contain multiple IoT components, such as a jet engine equipped with thousands of sensors. In short, the Internet of Things network is an advanced concept of the Internet network so that all things in our life (of various types, shapes and sizes) possess the ability to connect

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to the Internet or communicate with each other to collect data and share it to perform specific functions.

Kevin Ashton defines IoT as "The Internet of Things' means sensors connected to the Internet and behaving in an Internet-like way by making open, ad hoc connections, sharing data freely and allowing unexpected applications, so computers can understand the world around them and become humanity's nervous system" [2].

2. LITERATURE REVIEW

Many technical communities are vigorously pursuing research topics that contribute to the IoT, where today, IoT technology is embedded in many aspects of our lives. In this context, the authors in [3] trying to integrate IoT technologies into the smart home system, which has proposed a new idea of applying IoT technologies to smart home, from which many applications can be integrated into the system through a unified interface. Agents are proposed to communicate with appliances via RFID tags.

The radix and vision of IoT are described in [4] the authors investigated and analyzed applications, challenges and future orientation of IoT. Isa Shemsi [5] and the authors in [6] designed and implemented a smart home using the Cisco Packet Tracer tool, where they used the home gateway for home automation and record smart devices for monitoring them and Microcontroller (MCU-PT) to connect various sensors as well as IoE devices. The authors in [7] show improved home automation with the help of IoT. For calculating response time of IoT, he needed a platform Cisco packet tracer which is built by Cisco. The IoT management platform was proposed in [8]. The platform offers management solution for things, especially the constrained objects which have limited account and power resources. Also, he demonstrates some of the monitoring and control management capabilities that the proposed platform provides.

Malche Timothy, and Maheshwary Priti [9] described Frugal Labs IoT Platform (FLIP) for building IoT enabled Smart Home. He discussed functions of Smart Home and its applications and introduces FLIP architecture with implementation of Smart Home services using FLIP through a proposed system. The authors in [10] present an approach to the development of Smart Home applications by integrating Internet of Things (IoT) with Web services and Cloud computing.

The author in [11] introduces a lower cost, safe and scalable home monitoring and environmental management system. It employs an embedded micro-web server in Arduino microcontroller, with remote access to and control of devices and appliances via IP connectivity. These devices can be operated through a web application or Smartphone App based on Bluetooth Android. Any Android-based smartphone with Bluetooth and Wi-Fi support can be used at home to access and monitor devices.

Smart Home Automation Based on Voice Command Using Smart Phone is defined in [1]. The system is ideal for seniors and people with disabilities, particularly those who live alone and because they know a voice so that it is safe. Equipped to monitor all lighting and electrical home appliances in your home or office using voice instructions. The end-user requirements are the Android Operating System (OS) device. The link between the microcontroller and the smartphone is through Bluetooth. Home Automation System is built in [12] using Android mobile OS with Bluetooth Modul. Remote control function is accomplished via a smartphone or tablet that is powered by Android OS. In the Bluetooth smartphone Android App serves as a transmitter that sends commands to the Bluetooth receiver module.

The Authors in [13], developed an automation system for home appliances using a PC / Laptop or Android mobile phone. Vision of IoT, IoT drivers and the different sensors and technologies used in IoT are discussed in [14]. The authors in [15] proposed a smart office automation system for energy saving based on the Light Dependent Resistor (LDR), and Pyroelectric Infrared (PIR) sensors.

3. PROPOSED SMART HOME SYSTEM AND ARCHITECTURE

In this paper, we explained how smart home was implemented through the simulation framework based on the Cisco packet tracer version 7.3.0. Cisco Packet Tracer is a tough Cisco system Academy network modeling application which can simulate/create a network without a physical network. It has a drag and drop interface that is easy to use while configuring complex networks [16], [17]. Along with the various classical network devices available in the previous versions, Packet Tracer version 7.0.0 received an important upgrade with Smart objects and IoT components.

Additionally, Cisco Packet Tracer (version 7.2) can operate as a hybrid network that combines real networks with virtual networks [18]. This latest version of cisco packet tracer (7.2) is also added to MCU-PT board single boarded computers (SBC-PT) [19], offering programming environment to power connected devices. Newly released Packet Tracer advantages are [6]: Provides the practical IoT machine simulations and visualizations. Allows users to plan, create, customize smart homes, smart cities by supplying them with various smart objects. Provide board for the control of intelligent objects. Allow students to explore the concepts of IoE principles. Provide sensor detector.

Cisco packet tracer included different smart objects used for home automation such as chic windows, chic fans, chic lights, chic doors, chic garbage doors, lawn sprinklers, fire sprinklers, web cams and various sensors. The Microcontroller (MCU-PT) and Home Gateway are used for controlling the objects and sensors,

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since it provides programming environment for controlling objects connected to it and provide controlling mechanisms by registering smart device to Home Gateway respectively [5]. To implement smart home using cisco packet tracer, we used different sensors, smart devices and detectors to make smarter.

Figures (1 and 2) represent the home architecture that connected each other using wireless and wired medium. The Figures from (3 to 6) represent the Home Gateway and IoT device Settings. Figure 7 shows the main IoT Homepage.

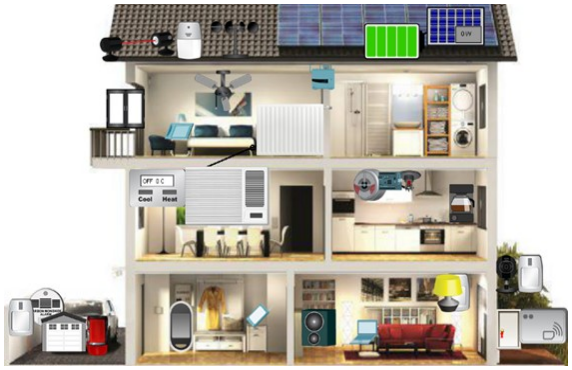

Figure 1 Smart Home architecture on physical workspace when IoT devices status OFF, where IoT devices have been placed in the appropriate position in the house to suit the needs of the home residents and according to the proposed design

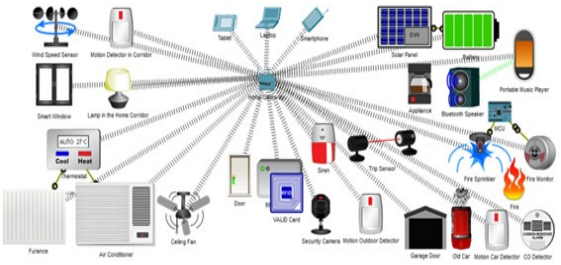

Figure 2 Smart Home architecture in logical Workspace when IoT devices status ON. As shown, all IoT devices are wirelessly connected to the Home Gateway

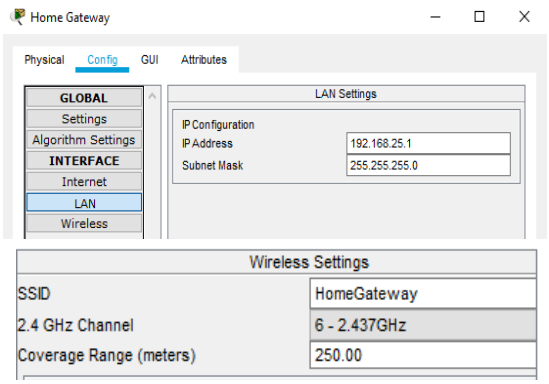

Figure 3 Home Gateway Settings

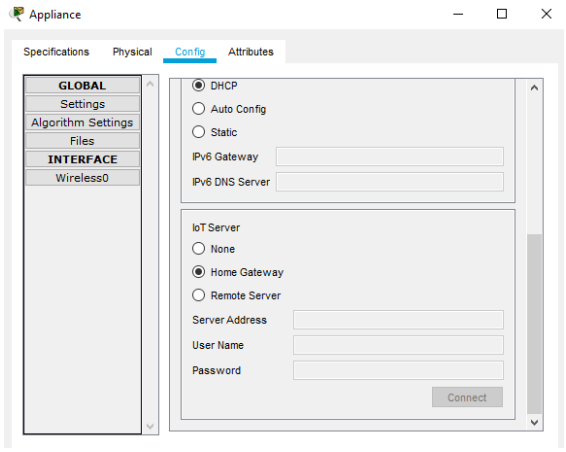

Figure 4 Registering IoT Device to Home Gateway

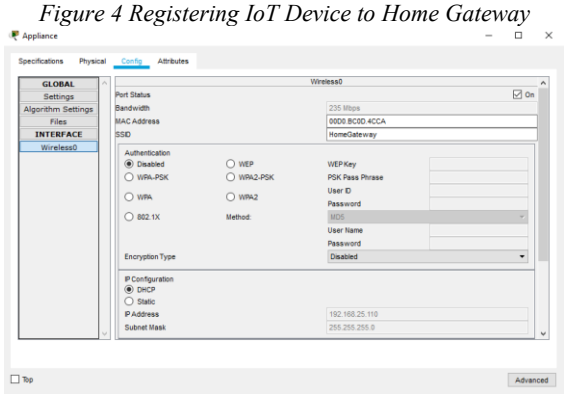

Figure 5 Configure Wireless Settings for the IoT Device

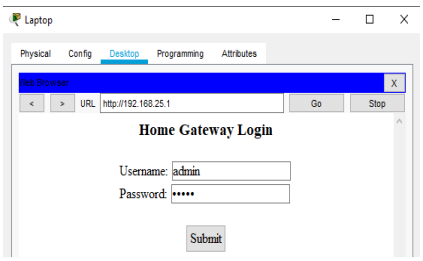

Figure 6 Home Gateway Laptop Login

As is shown in Figure 8 the status of the Thermostat is Auto and now the Furnace is ON because the temperature is 12.9°C, as it turns on the Air Conditioner automatically when the room temperature is greater or equal to 22 degrees, or it turns on the Furnace at a temperature of fifteen or less, otherwise the two remain off.

Figure 9 shows the battery and solar panel status from the main IoT Homepage, where shows both amounts of electricity produced by the solar panel and the remaining power in the battery in real-time. Figure 10 shows the performance and response of motion sensor and webcam. When the motion sensor detects any moving objects, it sends a command to turn on the webcam. Figure 11 shows the pre-set conditions from smart home owner made on home gateway to control IoE device.

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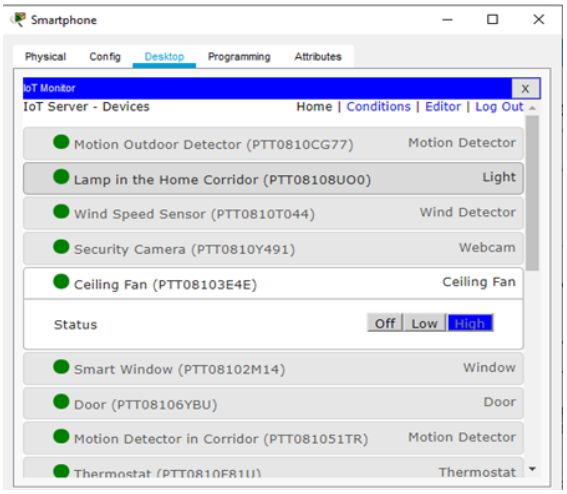


Figure 7 IoT Homepage from the Smartphone to check the status and monitor the list of all connected IoT devices; and the figure shows also, the status of the Ceiling Fan

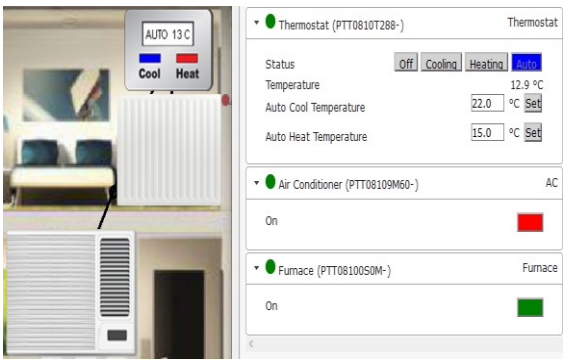


Figure 8 Simulation of Thermostat from IoT Homepage

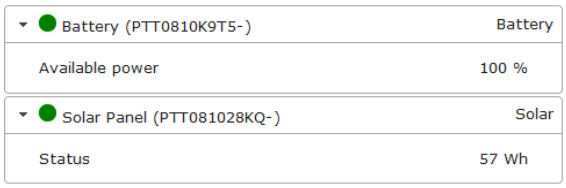


Figure 9 Battery and Solar Panel Status from the main IoT Homepage

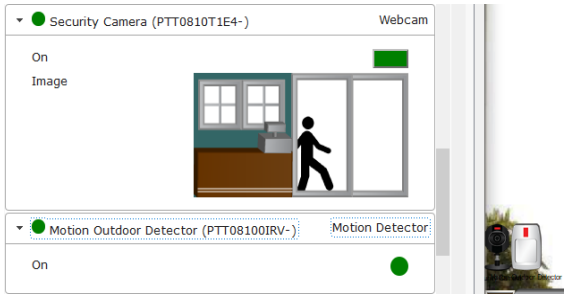
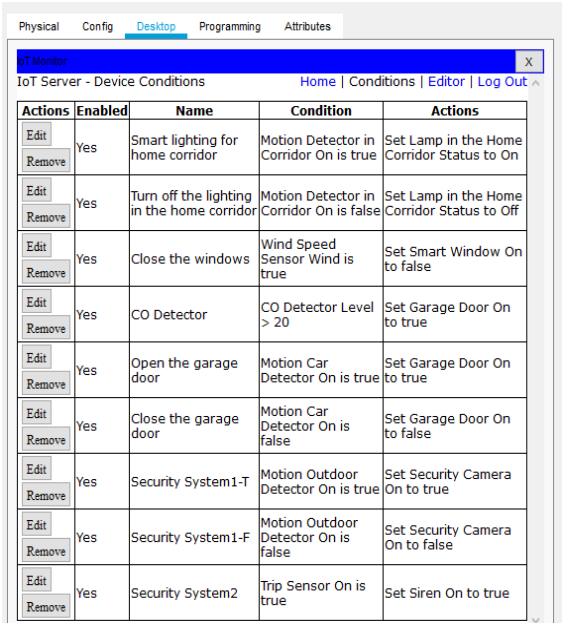


Figure 10 the case when moving objects were detected by motion sensor and webcam is showing images



Actions	Enabled	Name	Condition	Actions
Edit Remove	Yes	Smart lighting for home corridor	Motion Detector in Corridor On is true	Set Lamp in the Home Corridor Status to On
Edit Remove	Yes	Turn off the lighting in the home corridor	Motion Detector in Corridor On is false	Set Lamp in the Home Corridor Status to Off
Edit Remove	Yes	Close the windows	Wind Speed Sensor Wind is true	Set Smart Window On to false
Edit Remove	Yes	CO Detector	CO Detector Level > 20	Set Garage Door On to true
Edit Remove	Yes	Open the garage door	Motion Car Detector On is true	Set Garage Door On to true
Edit Remove	Yes	Close the garage door	Motion Car Detector On is false	Set Garage Door On to false
Edit Remove	Yes	Security System1-T	Motion Outdoor Detector On is true	Set Security Camera On to true
Edit Remove	Yes	Security System1-F	Motion Outdoor Detector On is false	Set Security Camera On to false
Edit Remove	Yes	Security System2	Trip Sensor On is true	Set Siren On to true

Figure 11 Pre-set conditions from Smart Home Owner made on Home Gateway to control IoE Device

Figure 12 shows RFID system conditions and the concept is when the authorized RFID passes onto the reader, the door lock will open and otherwise it will re-main locked. Figure 12 shows the RFID System.

Edit Remove	Yes	RFID System-Waiting	RFID Reader Card ID = 0	Set RFID Reader Status to Waiting Set Door Lock to Lock
Edit Remove	Yes	RFID System-Valid	RFID Reader Card ID = 2020	Set Door Lock to Unlock Set RFID Reader Status to Valid
Edit Remove	Yes	RFID System-Invalid	Match all: • RFID Reader Card ID != 0 • RFID Reader Card ID != 2020	Set RFID Reader Status to Invalid

Figure 12 RFID System Conditions

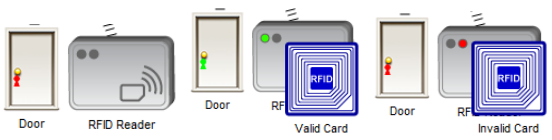


Figure 13 RFID System Cases (Waiting-Valid-Invalid)

As shown in Figure 14 car was used, smart garage door, motion detector, carbon monoxide alarm, but the car was used only to affect the environmental variable of the simulation as a carbon monoxide increase. For this case, when the CO level > 20% alarm is turned on, the garage door is opened, when the door is opened, the gas will decrease, then the alarm will go off. The garage door will also open when the motion detector detects the car coming in and stays open for 120 seconds.

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TABLE I: DEVICES AND MACHINES USED FOR DESIGN

No.	Device or Machine	Function
1	Smart Phone, Tablet, Laptop	Connect to home getaway to access smart object
2	Home Gateway	Used to register smart object and give IP address to it, then you can remotely managed through a web interface hosted
3	MicroController (MCU-PT) Board	Microcontroller board is used to interconnect different smart object and provide programming environment with different language those are JavaScript, python and visual basic, to control the connected smart object
4	Fire monitor	Detect IR in the range of fire
5	Fire Sprinkler	A Sprinkler that puts out fire
6	Fire	Used to simulate different scenario in home design since it affects fire
7	Outdoor Security Camera	Monitoring what's happening outside, it's works when the motion outdoor detector detect motion
8	Motion Outdoor Detector	Connect to home getaway and provide Detection of motion outside the home
9	Trip Sensor	Is a type of motion detector that can detect movement across a laser beam, used for security
10	Siren	Provide sound for event on the trip sensor
11	RFID Reader	Read the ID of an RFID Card, Transmit that ID to the registration server
12	RFID Card	Interacts with the RFID Reader based on some conditions
13	Smart door	Connect to home getaway and provide Function based event
12	Carbon Monoxide Detector	Detects the level of the carbon monoxide, alarm will turn on when the level > 20%
14	Old car	Used to change the Carbon Monoxide level, Carbon Dioxide and smoke level
15	Motion Car Detector	Connect to home getaway and it senses the movement of the car
16	Garage Door	Automatically opens when there is a car coming, it remains open for 120 second
17	Smart window	Used to control the window remotely Affects Argon, Carbon Monoxide, Carbon Dioxide, Hydrogen, Helium, Methane, Nitrogen, O2, Ozone, Propane, and Smoke, wind speed
18	Wind Speed Sensor	It measures wind speed and provides data reporting average wind speed
19	Smart light in home corridor	Used to give light in the corridor when there is movement
20	Motion Detector in Corridor	Connect to home getaway and provide Detection of motion in the home corridor
21	Smart thermostat	Used to sense the temperature of the home
22	Air conditioner	Reduce temperature if temp >=22 °C
23	Furnace	Increase temperature if temp <=15 °C
24	Appliance	Instrument / Device uses at home
25	Solar panel	Generates power based on the amount of SUNLIGHT in the environment Sends generated power to another device such as Battery
26	Battery	Send power to other devices
27	Ceiling fan	Used to ventilate the home environment
28	Portable Music Player	Plays music through Bluetooth capabilities
29	Bluetooth Speaker	Plays sound through Bluetooth from a Portable Music Player

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Figure 14 Sample from Smart Home Layout

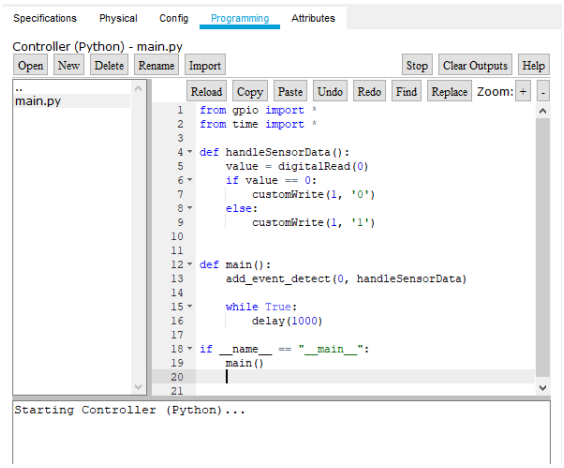

Figure 15 MCU programming environment

In fire sprinkler system as shown in Figure 16, fire monitor detects flames by checking for a property and finding if the "IR" property value is in the range the detector considers a fire and outputs a digital signal of High to the MCU. The MCU will be send a digital signal of High (see Figure 15) to fire sprinkler to raises the water level. Table 1 shows the devices and machines used for design.

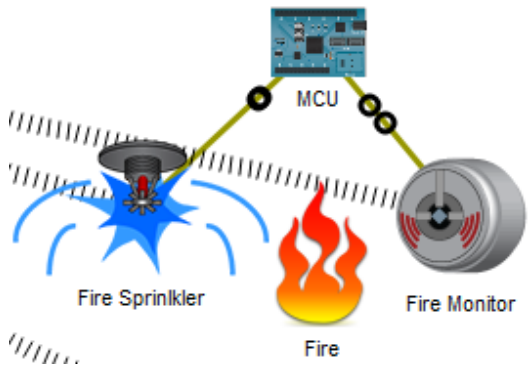

Figure 16 Fire Sprinkler System

4. CONCLUSION

The idea of proposed model of smart home in this paper can support many home automation systems. The smart home includes a connection between wireless communication, sensors, monitoring and tracking devices. Smart homes are a huge system that includes multiple technologies and applications that can be used to provide easy home security and control. The proposed system discussed the designed modules such as sensors circuits, home monitoring and tracking via IP cameras, mobile notifications and home navigator. A number of experiments have been carried out on the proposed smart home. These experiments show how to detect a fire, CO monoxide. As well as, how to detect any intruder to the home, detect and control the weather of any room, and how to secure the home through an access code. This design also illustrates the way to monitoring and tracking the home through an IP camera, and the way to send notifications to the homeowner about the actions in the home. In addition, this system has shown the idea of making a navigator in the home to measure the temperature in all rooms and detect any fire happens and to detect any motion in the home by using ultrasonic sensors.

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Authors Biography

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Dr. Salah Abdulghani Alabady received the B.Sc. degree in Electronic and Communications Engineering and the M.Sc. degree in Computer Engineering from Mosul University, Mosul, Iraq, in 1996 and 2004 respectively, and the PhD degree in Wireless Networks from School of Electrical and Electronic Engineering, Universiti Sains Malaysia, Pulau Penang, Malaysia, in May 2014. He was a Lecturer with Computer Engineering Department, Mosul University, Mosul, Iraq, from 1999 until October 2010. Currently, he is Assistant Professor with the Computer Engineering Department, Mosul University, Iraq. His research interests include error correction codes, wireless network coding, joint network - channel coding and cross layer in wireless sensor networks. Dr. Salah has participated in many scientific activities as a reviewer in many respectable publishers such as IEEE, IET, Elsevier, and Springer and many others. Currently, he has 39 published papers

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