INTERNET OF THINGS SIMULATION USING CISCO PACKET TRACER

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İZMİR

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I would also like to thank my friends and family that provided me encouragement and support throughout this period.

ABSTRACT

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Nowadays, the term IoT (internet of things) have become extremely important in our life. This technology is used in many fields such as education, health, industries, agriculture and infrastructures. In order to learn and understand how this technology works, many practical learning tools are used.

The aim of the thesis is to introduce a iot simulation tool, where student can simulate or build and manage the systems for better understanding of the philosophy behind iot networks.

The tool used is Cisco packet tracer which is a software developed by Cisco that is used to create and simulate a virtual network, basically a wireless network, without the need for any network hardware.

The tool is free of charge, and suitable to work with almost all the operating systems. Cisco packet tracer allows users to have a practical networking technology knowledge.

In this thesis, “Cisco packet tracer” is used to design an internet-based home automation system or smart home.

ÖZET

CİSCO PAKET İZLEYCİ KULLANARAK NESNELERİN İNTERNETİ SİMÜLASYONU

Günümüzde IoT (nesnelerin interneti) terimi hayatımızda son derece önemli hale geldi. Bu teknoloji eğitim, sağlık, sanayi, tarım ve altyapı gibi birçok alanda kullanılmaktadır. Bu teknolojinin nasıl çalıştığını öğrenmek ve anlamak için birçok pratik öğrenme aracı kullanılır.

Tezin amacı, iot ağlarının arkasındaki felsefeyi daha iyi anlamak için öğrencilerin sistemleri simüle edebileceği veya oluşturabileceği ve yönetebileceği bir iot simülasyon aracı sunmaktır.

Bu çalışmada kullanılan araç; herhangi bir ağ donanımına ihtiyaç duymadan kablosuz sanal bir ağ oluşturmak ve simüle etmek için kullanılan Cisco tarafından geliştirilen bir yazılım olan, Cisco paket izleyicisidir.

Araç ücretsizdir ve hemen hemen tüm işletim sistemleriyle çalışmaya uygundur. Cisco paket izleyici, kullanıcıların pratik bir ağ teknolojisi bilgisine sahip olmalarını sağlar.

Bu tezde "Cisco paket izleyici", internet tabanlı bir ev otomasyon sistemi veya akıllı ev tasarlamak için kullanılmaktadır.

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ABBREVIATIONS

3GPP	3rd Generation Partnership Project
API	Application Programming Interface
APN	Access Point Name
ARPANET	Advanced Research Project Agency Network
CLI	Command Line Interface
DHCP	Dynamic Host Configuration Protocol
DNS	Domain Name System
GUI	Graphical User Interface
IaaS	Infrastructure as a Service
IoE	Internet of Everything
IoT	Internet of Things
ISP	Internet Service Provider
LAN	Local Area Network
NetAcad	Cisco Networking Academy
RFID	Radio Frequency Identification
RIP	Routing Information Protocol
SaaS	Software as a Service
POP3	Post Office Protocol version 3
Telnet	TELecommunications NETwork
SSH	Secure Socket Shell
DSL	Digital Subscriber Line
FTP	File Transfer Protocol
SMTP	Simple Mail Transfer Protocol
HTTP	Hypertext Transfer Protocol
TFTP	Trivial File Transfer Protocol
AAA	Authentication, Authorization, and Accounting
NTP	Network Time Protocol
SNMP	Simple Network Management Protocol
VOIP	Voice-Over-IP
SCCP	Signaling Connection Control Part

ISR	International Standard Recording
TCP	Transmission Control Protocol
UDP	User Datagram Protocol
BGP	Border Gateway Protocol(TCP/IP)
ICMP	Internet Control Message Protocol
IP	Internet Protocol
ARP	Address Resolution Protocol
NAT	Network address translation
GRE	Generic Routing Encapsulation
IPSec	IP Security
VPN	Virtual Private Network
HDLC	High-level Data Link Control
PPP	Point to Point Protocol
STP	Spanning-Tree Protocol
PPPoE	PPP Over Ethernet
DTP	Data Transfer Process
VTP	VLAN Trunking Protocol
QoS	Quality Of Service
CDP	CRL Distribution Point [Microsoft
WEP	Wired Equivalent Privacy
SLARP	Serial Line Address Resolution Protocol
WAN	Wide-Area Network
WAP	Wireless Access Protocol
TCP/IP	Transmission Control Protocol/Internet Protocol
EAP	Extensible Authentication Protocol [Microsoft]
PKT	Packet Tracer file extension
PSK	Phase Shift Keying
SSID	Service set identifier

CHAPTER 1

INTRODUCTION

1.1. Introduction

Computer networks are considered to be very complex and difficult to implement and operate. Moreover, with IoT (internet of things) technology, where we connect any sort of devices on internet such as refrigerator, air conditioner, fan etc. this complexity becomes even higher. Many documents show that there are actually 13 billion IoT (internet of things) devices connected to the internet, and that there is a possibility that this number will go up to 30 billion in the next three years. [1]

This complexity of the network will give students some though time for learning and understanding how this technology work. Therefore, it is very important to provide a network learning and practical tools, where student can simulate or build and manage the systems for better understanding of the philosophy behind networks. [2]

Network simulation tools are used for testing how the network will work before being physically installed. There are many tools for network simulation: NS-2, TOSSIM, OMNeT++, J-Sim, Avrora, and the common one Cisco Packet Tracer. [9]

Cisco packet tracer is a powerful software created by Cisco Company for simulating virtual networks, especially wireless networks. Cisco packet tracer gives an environment where devices look what they do in reality, and this is very important for users especially students. They can monitor and interact with different wireless and IoT devices in virtual environment before working in real time. [3]

Working with simulation tools to learn how networks work give us both time and materials advantages and help decreasing the costs in education.

This thesis is organized as follows: the first part of the thesis is the introduction, the second part is focused on cisco packet tracer simulation tools, the third part of the thesis is about the implementation of smart home with cisco packet tracer, and the last part is conclusion and future research

1.2. IoT definition

Internet of things or internet of everything refer to the idea of thing (object), that are readable, recognizable, locatable, addressable through information sensing devices (sensor) and controllable via internet.

Things are physical objects with unique identifiers that are able to transfer data over the network. Examples of physical objects include vehicles, smart phones, home appliances, toys, cameras, medical instruments and industrial systems, animals, people, buildings, etc. [4]

Internet of Things is a new revolutionary and advanced technology where any object becomes smart object, and where they can communicate information about themselves without human intervention. The Internet of Things is expected to make a huge change in our lives; it will help us to perform our tasks and duties in a better way.

1.3. History and Evolution of IoT:

The very first idea of IoT started with Coca Cola vending machines in 1980s at the Carnegie Melon University, students from the department of computer science install micro- switches into the machine to see if the cooling devices was keeping the drinks cold enough and if there were available coke cans in the machine via internet. This first invention encourage further studies on interconnected machines. Later in 1990s, with a TCP/IP protocol John Romkey connected a toaster to the internet for the first time. [5]

In 1991 at Cambridge University, Scientist developed a system to check to amount of coffee available in the coffee machine. The idea was to use the webcam to take picture of the coffee pot three time a minute and send to local computer located in their lab so everyone could see the amount of coffee. [5]

In 1991, Kevin Ashton introduce the concept of the internet of things (IoT) in a presentation paper for Procter & Gamble. In the presentation, he explained the internet of things as a technology that connected devices Using RFID (radio frequency and identification) technology. [5]

In 2008, scientists from 23 countries were regrouped in Switzerland at the first international conference on the internet of things, to discuss about the RFID, short- range wireless communications and sensor networks.

2010 was the true birth of the internet of things according to cisco because of the number of the interconnected devices. They also said that the number of interconnected devices passed the number of people on earth. [5]

In 2015, the number of connected devices has significantly exceed the number of people. We can see in the figure above that in the present year (2020) they are 50 billion and the world population is 7.6 billion people. This show that the number of connected devices are six times more the number of human.

It is expected that in the future, all things will be able to connect to each other. Things not including just electronic devices but also books, shoes, foods, water etc. [5]

Table 1.1. Cisco Prediction of Connected Devices

(source: Cisco- the internet of things. How the nest evolution of the internet is changing everythings)

Connected devices by 2020

Cisco IBSG, April 2011

World population	6.3 billion	6.8 billion	7.2 billion	7.6 billion
Connected devices	500 million	12.5 billion	25 billion	50 billion
Devices per person	0.08	1.84	3.47	6.58
	2003	**2010**	**2015**	**2020**

More connected devices than people

1.4. IoT (Internet of Things) Applications:

Internet of things is the technology that will make a big impact in our life. This technology is utilizing in many sector for instance agriculture, energy healthcare, transports, and many more.

In this section, I will describe some of the real world applications of internet of things.

Industrial Internet of Things (IIoT):

Internet of things is used in the industry field to improve the productivity and performance. For example, the internet of things devices can be used to monitor and control the process of the factory and for maintenance; it can be used to detect corrosion inside a refinery pipe, or to predict about the malfunctions of some equipment in order to provide maintenance services before it get too late. The use of internet of things in the industries will help variety of industries including manufacturing, food industries, automotive industries, etc. to get work done easily. [6]

Internet of Medical Things (IoMT):

The medical sector will be the one to benefit the internet of things technology the most.

Internet of things in healthcare give the possibility to the doctors possible to control patient conditions anywhere anytime over network in order to provide monitoring, analysis and remote configurations through smart devices such as heart monitors and pace makers. Many others internet of things devices can be used to control our health such as fitness trackers and smart watches etc. [6]

Smart Cities:

Smart cities refer to a city where internet of things devices are used to control and monitor the transportations and infrastructures in the city. Internet of things devices can also be used in smart city to control others sectors or activities in the cities rather than transportations or infrastructures such as controlling the quality of the water, or analyzing and monitoring the energy system, and many more. [6,]

Smart Homes:

Smart home refer to a home equipped with smart appliances, fridge, air conditions, light, camera, fan, smart thermostats, door locks etc. that can be remotely control and manage through internet using smart phone or computer. The possibility to manage to manage the home equipment from distance offer homeowner security, comfort and convenience. Smart home help saving energy and avoids some accidents, homeowner can remotely monitor the camera, home alarm system, and detection system to check if there is any violations for security reason. [6, 7]

Smart Cars:

Smart car is a system where all the functionalities of the car can be remotely control by a computer or a smart smartphone with the use of different sensors. With This particular internet of things application, we can check the car oil level, radiator water, and even being capable to drive the car from distance. [7]

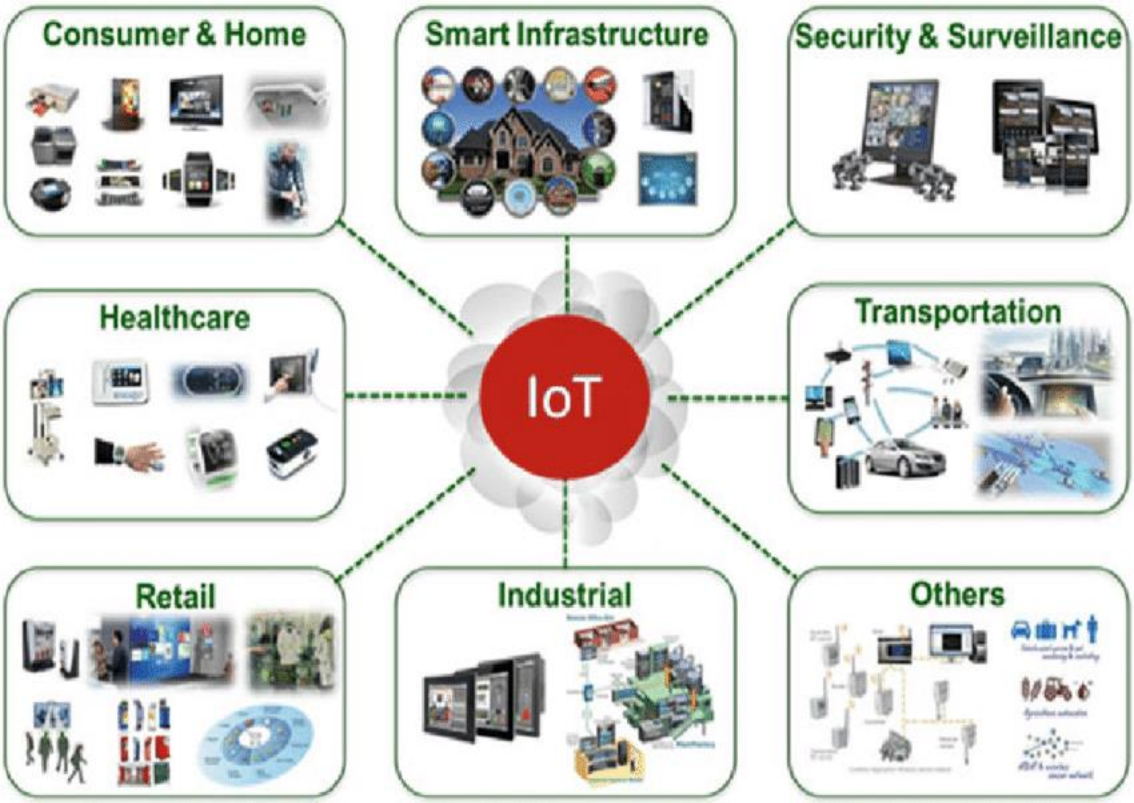

Figure 1.1. Iot Applications

(Source: researchgate.net)

CHAPTER 2

CISCO PACKET TRACER

2.1. Cisco Packet Tracer Overview

Cisco packet tracer is a powerful virtual network simulation tool used to learn and understand different concept in computer networks. The tool is developed by Cisco in order to allow students or user to get practical networking technology knowledge.
Cisco packet tracer provide user / student to design and simulate a network by using virtual devices such as hub, router, switches etc. In cisco packet tracer, the simulation works without having any physical network. [2,3]

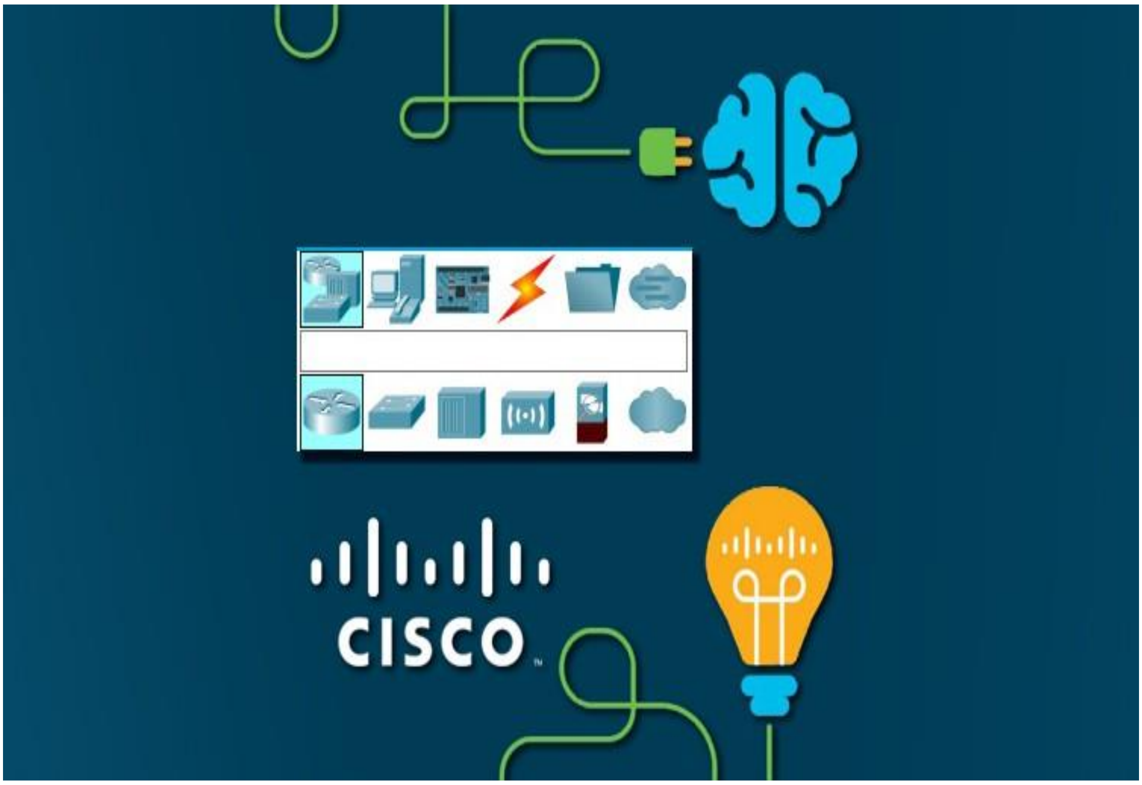

Figure 2.1. Cisco Packet Tracer Interface

2.2. Packet tracer Workspaces:

Cisco packet has two Workspaces: one is Physical and the other one logical. The logical view allow user to place and connect virtual network devices while the physical view gives a graphical representation of the virtual network devices.

In the physical view of the devices, we can add additional modules to an available slot in the devices as we can see in the Figure 2.2. bellow.

The good thing about this particular simulation tool is that it provide an environment where devices resemble to devices in the real world. This is very important because it give user the possibility to be familiar with devices before working with the real equipment. [3]

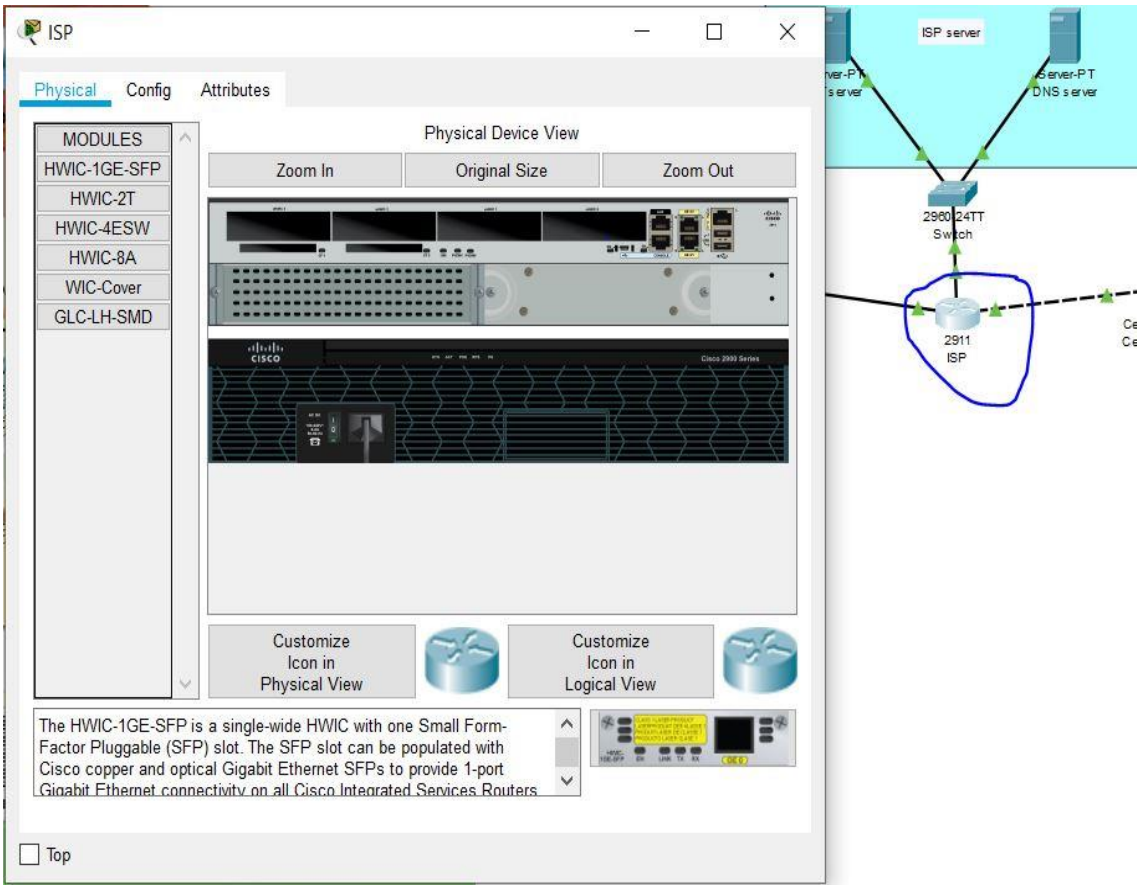

Figure 2.2. Physical View of ISP Router

2.3. Packet tracer Mode

The tool also provide two mode, which are real time mode, and simulation mode.
In the real time, students/ user can have a clear vison of how the devices behaves. In this mode, devices behave as real devices.
In the other hand, the simulation mode help students / user to understand the fundamental concept behind the network operations. This mode permit user to see and control time intervals, and to visualize the propagation of data across a network. [3]

2.4. Cisco devices configuration methods

Cisco packet tracer allow us to configure devices using two options: config tab or CLI tab (command line interface).
With command line interface, we configure devices using cisco command line. The advantage of using the command line interface is that, the commands we use to configure devices virtually are the same command we use with the real devices. [8]
The Figure 2.3 below represents a router configuration using a Command line interface (CLI).
The config tab did not required any cisco commands knowledge. Configuration with config tab is done through a graphical interface. This configuration method can be use in the situation where user does not have enough time and want to configure devices quickly. This technique can help us saving time during configuration. [8]
The Figure 2.4 represent a router configuration with Config Tab.

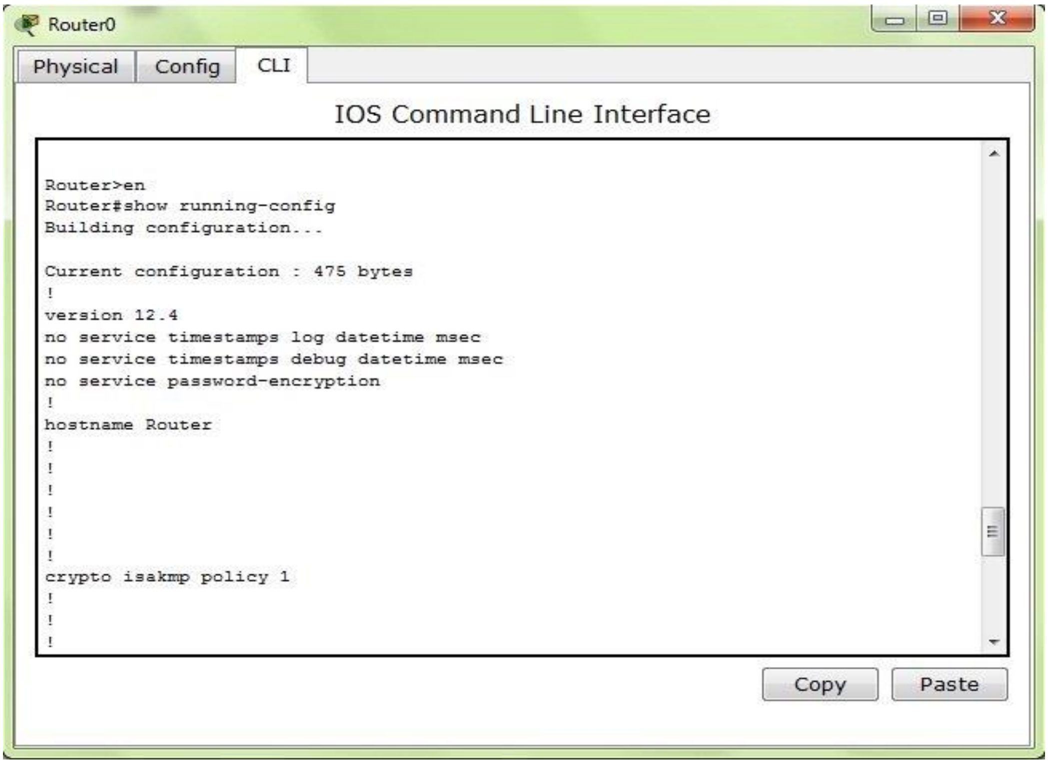

Figure 2.3. Cisco Packet Tracer Command Line Interface Tab

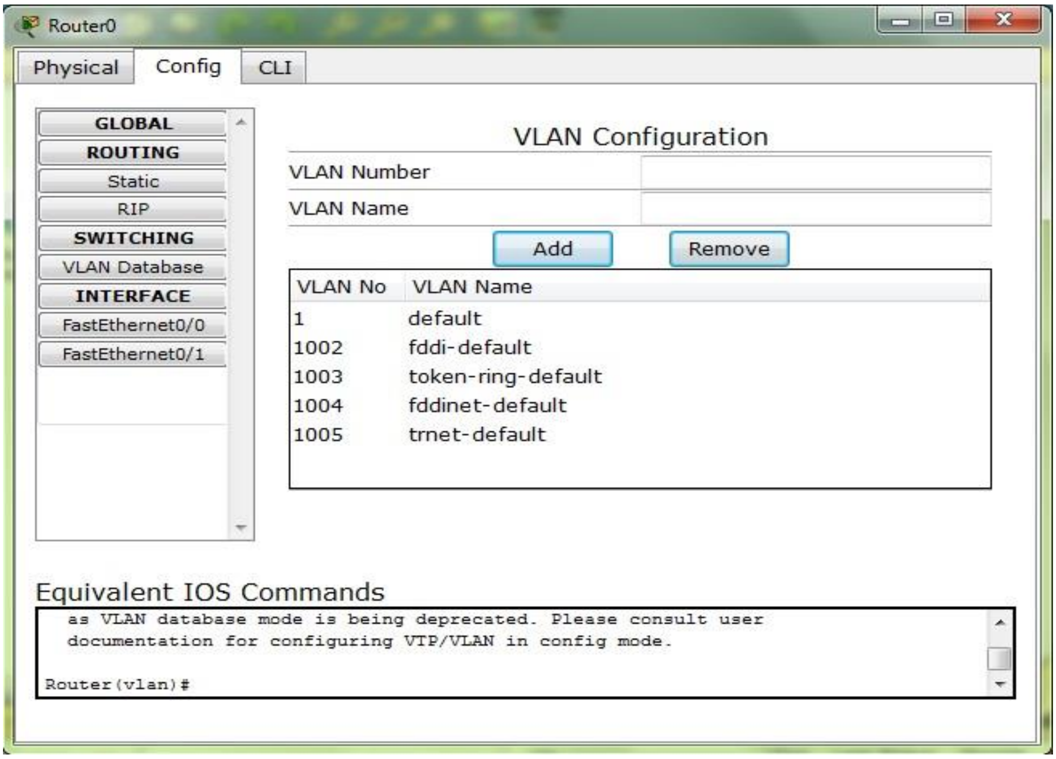

Figure 2.4. Cisco Packet Tracer Config Tab

2.5. Cisco packet tracer supported protocols:

Cisco packet tracer support different protocols. The table below show the lists of protocols supported by packet tracer. [3,8]

Table 2.1. Protocol Supported by Cisco Packet Tracer

Layer	Protocols
Application	FTP,SMTP, POP3, HTTP, TFTP, Telnet, SSH, DNS, DHCP, NTP, SNMP,AAA, ISR VOIP, SCCP config and calls ISR command support, Call Manager Express
Transport	TCP and UDP, TCP Nagle Algorithm & IP Fragmentation, RTP
Network	BGP, IPv4, ICMP, ARP, IPv6, ICMPv6, IPSec, RIPv1/ v2/ng, Multi-Area OSPF, EIGRP, Static Routing, Route Redistribution, Multilayer Switching, L3 QoS, NAT, CBAL, Zone-based policy firewall and Intrusion Protection System on the ISR, GRE VPN, IPSec VPN
Network Access/ Interface	Interface Ethernet (802.3), 802.11, HDLC, Frame Relay, PPP, PPPoE, STP, RSTP, VTP, DTP, CDP, 802.1q, PAgP, L2 QoS, SLARP, Simple WEP, WPA, EAP

2.6. Cisco packet tracer and Internet of Things:

The last version of cisco packet tracer included some new feature that can help us to perform internet of things simulation. Those new feature are smart devices, sensor, actuator and microcontroller. [9]
Some of those smart devices included in packet tracer are smart windows, smart fan, smart light, alarm siren. We can also find some sensors such as water level, temperature, humidity, carbon dioxide. [9, 10]
One most important thing with the new version is that, all the devices can be programmable using different programming languages that are phyton, javascript and blocky. In addition, they can all be connected through wired cable or through wireless.

There are different cabling options in the new packet tracer, which are copper straight cables, copper crossover cables, and optic fast-Ethernet cables and IoT custom cables. Nevertheless, we can also choose the auto cabling option where the tools automatically choose the suitable cable to connect two devices. [10]

The internet of things devices in the Cisco Packet tracer can be used to build and simulate different internet of things application such as smart home, smart industry, smart city etc.

The benefit of using cisco packet tracer is that, user can interact with the devices the same way they do in the real devices. In addition, with it multiuser functionality, multiuser can work together to build virtual network through a real network. [8]

This thesis work is only focusing on using the smart devices in the new version of the packet tracer to implement a smart home or internet based home automation system

The Figure 3.1 bellow show some different devices include in the new version of cisco packet tracer.

Figure 3.1. Cisco Packet Tracer Smart devices

CHAPTER 3

SMART HOME IMPLEMENTATION

3.1. Smart home overview

Smart home is a home equipped with different smart objects such smart fan, smart light, coffee maker, smart windows that can be remotely controlled via a smartphone or computer through internet connection.

Smart home offer the homeowners convenience, savings, safety, and comfort.

Saving because the use of some smart objects such as smart thermostats and smart light can help for energy saving (reduce energy consumption) and reduce bills.

It is convenience because every tasks are done automatically, and safety is one of biggest benefits of a smart home, because you can remotely control the devices and see if there is a danger at any time in your home.

Comfort because of the possibility it offer, imagine that you have the possibility to turn on your air conditioner to cool down the place before you reach your home, and also the possibly to check if there are foods in your refrigerator, or even to check if some foods inside your refrigerator are expiring or finishing. [10, 12]

Smart home allows homeowner to manage all the home devices anywhere at any time.

3.2. Smart home implementation

The implementation of the smart home is done with the new version of packet tracer, precisely PacketTtracer 7.1.

The Table 3.1 below shows the lists of the different devices used for the simulation and their functions.

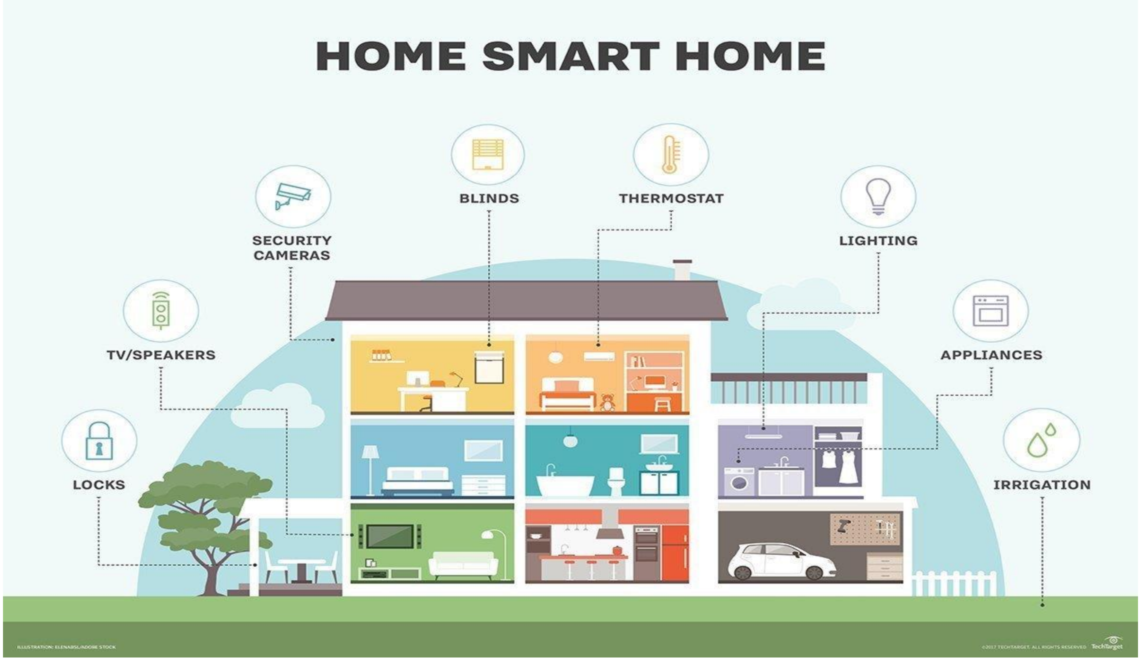

Figure 3.2. Smart home Application

(source: allaboutarchitecture.blog)

Table 3.1. Devices Used for the Simulation

No	Devices	Function
1	Router (2911) / ISP	Used to connects cellular network to home
2	Cable modem	Used to home gateway to cloud
3	Home gateway	Used for smart devices registration
4	IoT server	Used to control smart devices registered on it
5	DNS server	Used to access smart devices by domain name
6	Central office server	Used to connect cell tower to router and vice versa

(cont. on next page)

Table 3. (cont.).

7	Cell tower	Used to connect the smartphone to the internet
8	Smart phone	Used to remotely access smart devices
9	Fan	Used to ventilate home
10	camera	Used to control activities at home
11	Smart light	Used for lightning the home
12	Smart door	Used in order to open and close the door from distance
13	Smart windows	Used to control the windows from distance
14	Smart siren	Used to make sound if anything happen at home
15	Motion detector	Used to detect motion
16	Air conditioner	Used for home cooling
17	Lawn sprinkler	Used the sprinkler the garden
18	Old car	Used in order to control the car from distance
19	Garage	Used to control the garage door
20	Solar panel	Used to provide energy to the home
21	Battery	Used with solar panel to provide energy
22	laptop	Connect to the home gateway to access the smart devices
23	Coffee maker	Used to control the coffee machine

3.2.1. Methodology of the design:

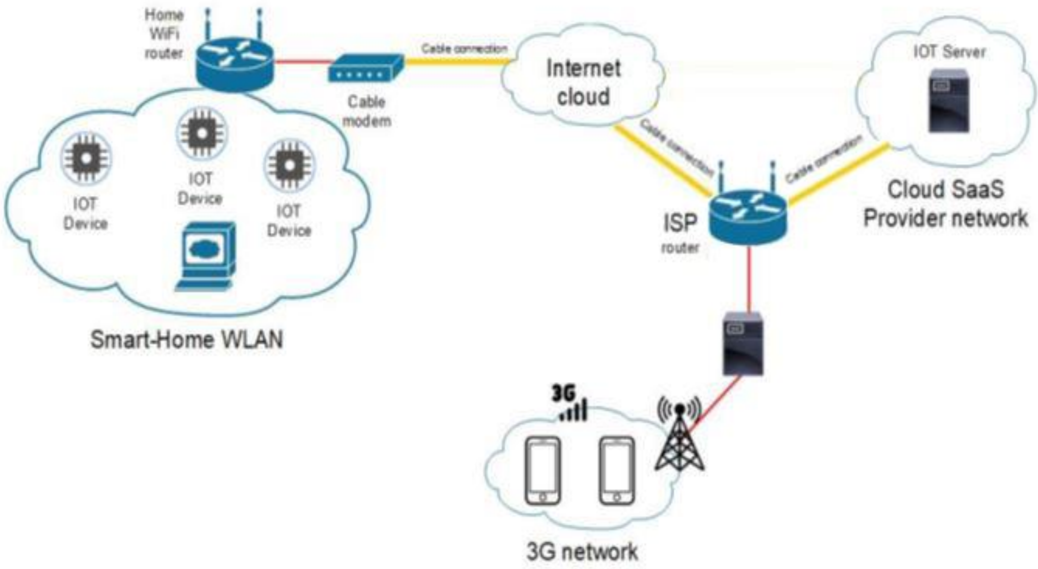

Figure 3.3. Methodology of the Design

The network topology used for the implementation of the smart home is represented in the Figure 3.3 above. The implementation consist of four part: the smart home, internet cloud, Iot server and 3G network. [11]

In the first part, we have a home network with different internet of things devices connected to the home gateway (home Wi-Fi router in the topology).

The second part of the network is the internet cloud (WAN) which is connected to the home Wi-Fi router through a cable modem in order to provide internet connection to the internet of things devices.

The third part concern the IoT (internet of things) server that register all the devices connected to it to provide more internet of things functionalities.

Then comes the last part of the topology “3G network”, the smart phone is connected to the cell tower for internet connection in order to remotely access the devices

3.2.2. Algorithm and Flow diagram

The Algorithm is explained as follows

Step 1: Start the project.

Step 2: Open the pkt file and save the file.

Step 3: Add the required components to the workspace

Step 4: Connect all devices in workspace using wireless connection.

Step 5: Configure the devices and setup internet service provider router.

Step 6: Add Home Gateway to the Network.

Step 7: Connect smart Devices to the Wireless Network.

Step 8: Add End User Device to the Network

Step 9: Stop

The flow diagram is explained as follows

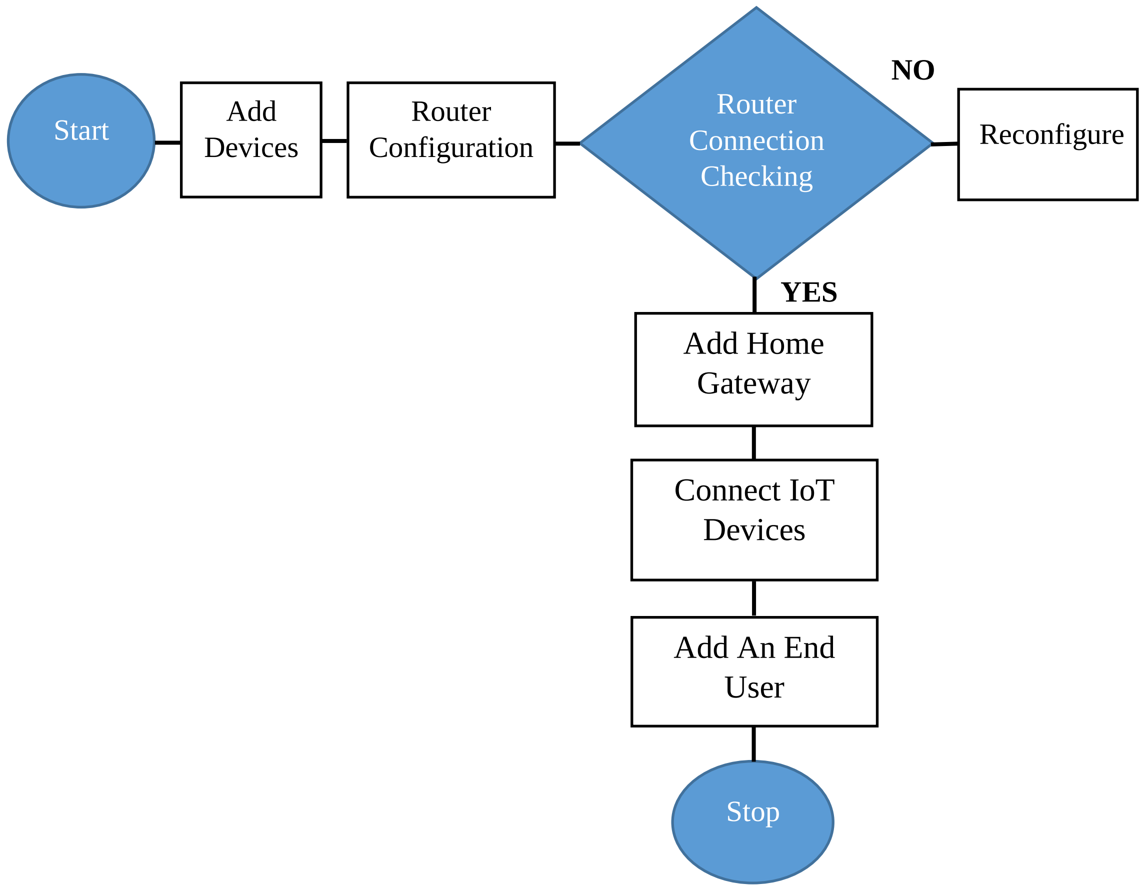

Figure 3.4. Flow Diagram

3.2.3. Devices configuration

This Figure 3.5 below show the simulation of the smart home with cisco packet tracer using the Methodology described in the previous page.

Home gateway, cloud, ISP (internet service provider) router, central office server, IoT (internet of things) Server, cell tower, smart phone and the car play an important role in the simulation.

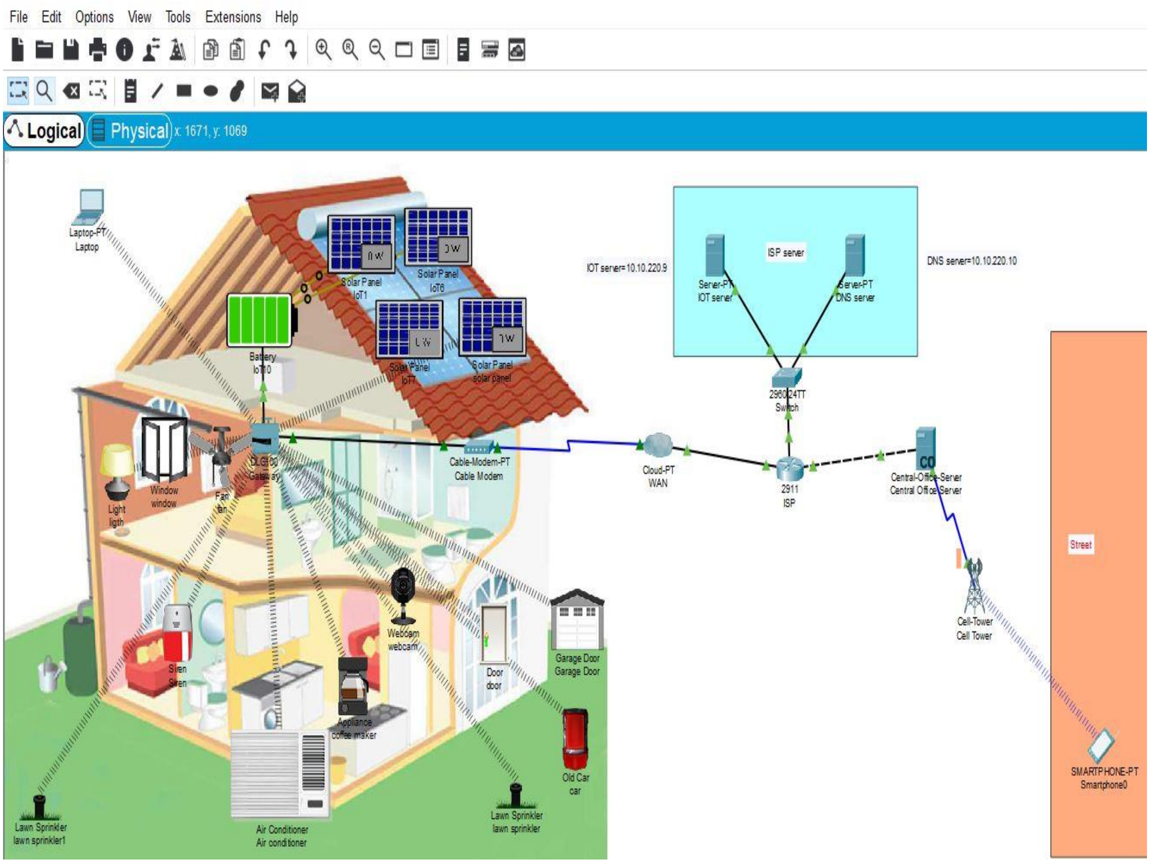

Figure 3.5. Smart home with Cisco Packet Tracer

-Home gateway = used for assigning IP address to the smart devices and for smart devices registration. The home gateway get the IP address from the ISP Router automatically after that the connection to the cloud WAN is established. Also all the smart object connected to the home gateway get an IP address from ISP router automatically via the cloud (WAN). The cable modem is used to connect the home gateway to the cloud.

The home gateway provide different programing environment to the devices that are java script, python, and visual basic. [12, 14]

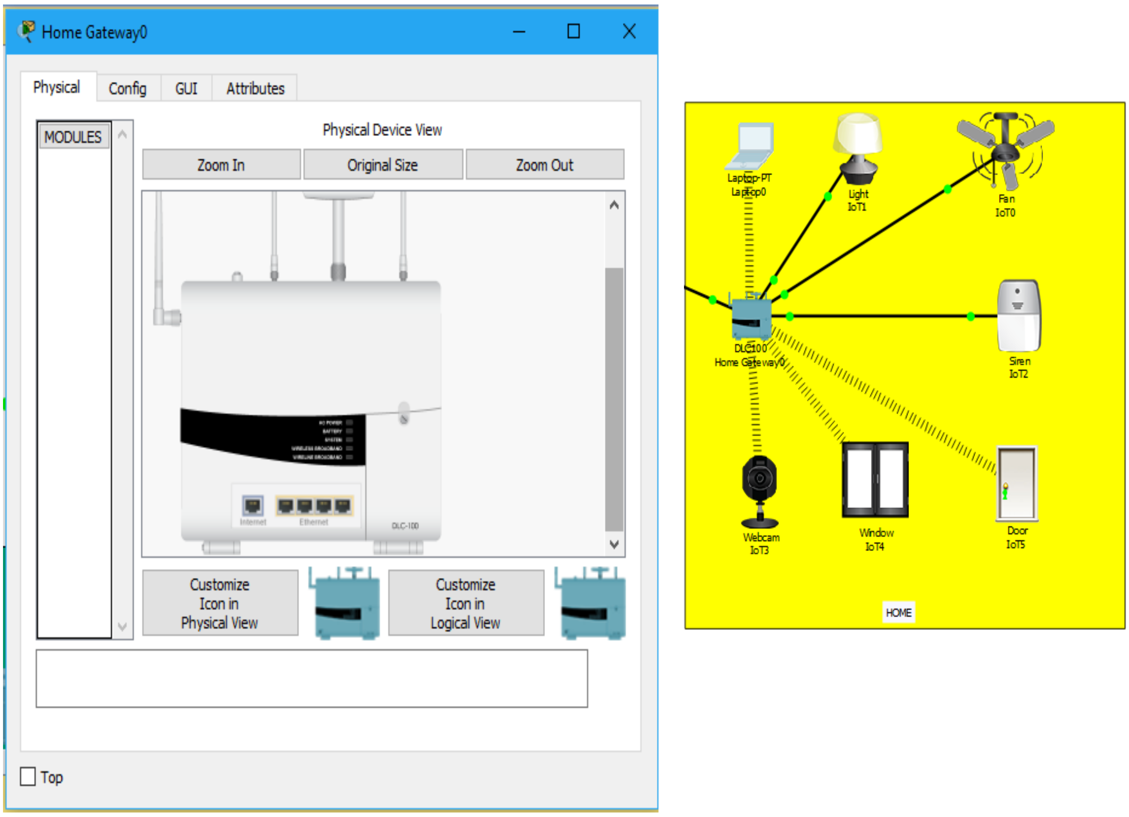

Figure 3.6. Home Gateway

In the Figure 3.6 above, we can see different smart objects connected to the home gateway using wireless or Ethernet cable connection.

There are four Ethernet ports in the home gateway plus a wireless access point with the SSID “home gateway”. We can configure WEP / WPA –PSK/ WPA2 protocols in the home gateway for the wireless connection authentication. [14]

In order to connect the devices to the home gateway, we must select wireless since the devices will be connected using wireless connection, then we specify the SSID of the home gateway in the devices.

This Figure 3.7 is the smart light configuration to the home gateway. The authentication is disabled to just to keep the configuration simple. So we repeated this configuration in all the devices.

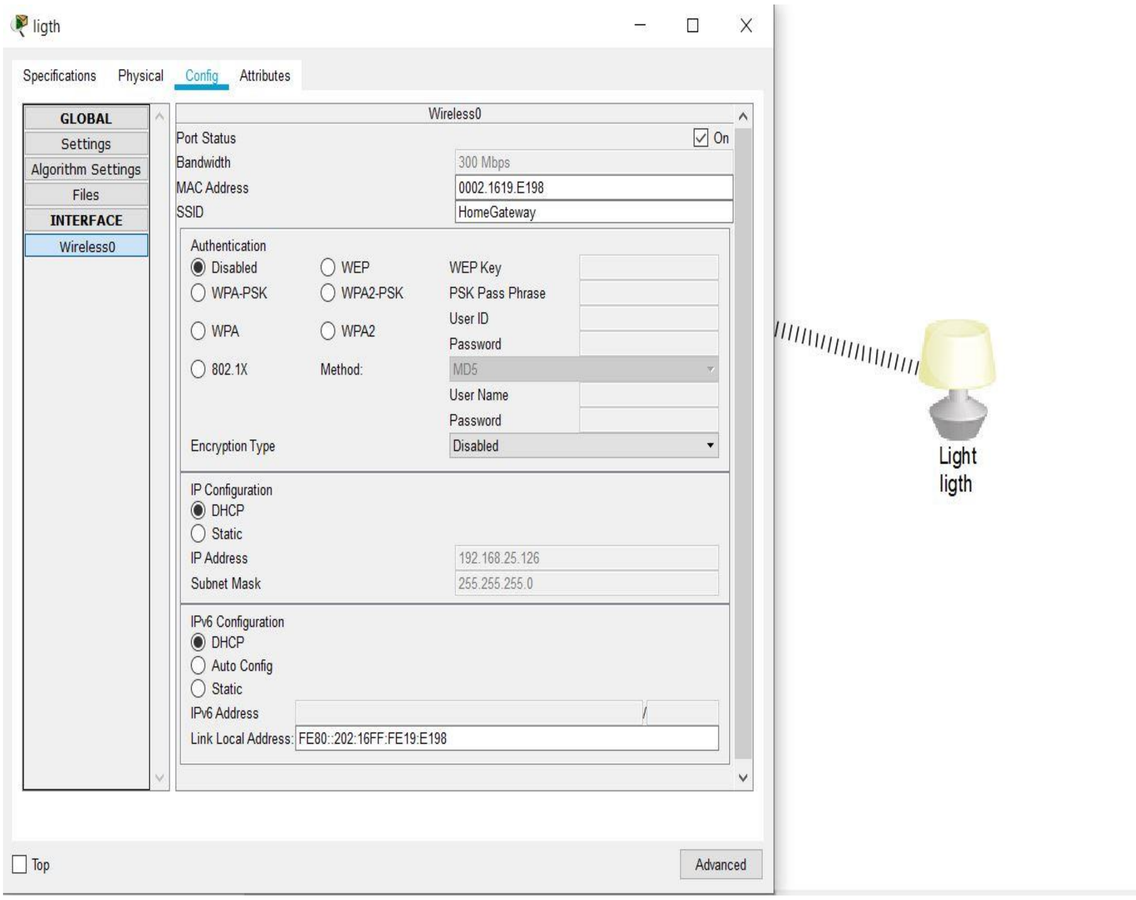

Figure 3.7. Smart Light Connected to the Home Gateway

ISP Router (internet service provider) as shown in Figure 3.8 is used to connect all the network interfaces to each other, the DHCP server is configured on it in order to assign IP address to every connected devices dynamically, whether they are smart devices or not smart in order to simulate the internet connectivity.[11]

The ISP router configuration is done with the cisco packet tracer command line interface. The configuration consist of hostname assigning and IP address configuration

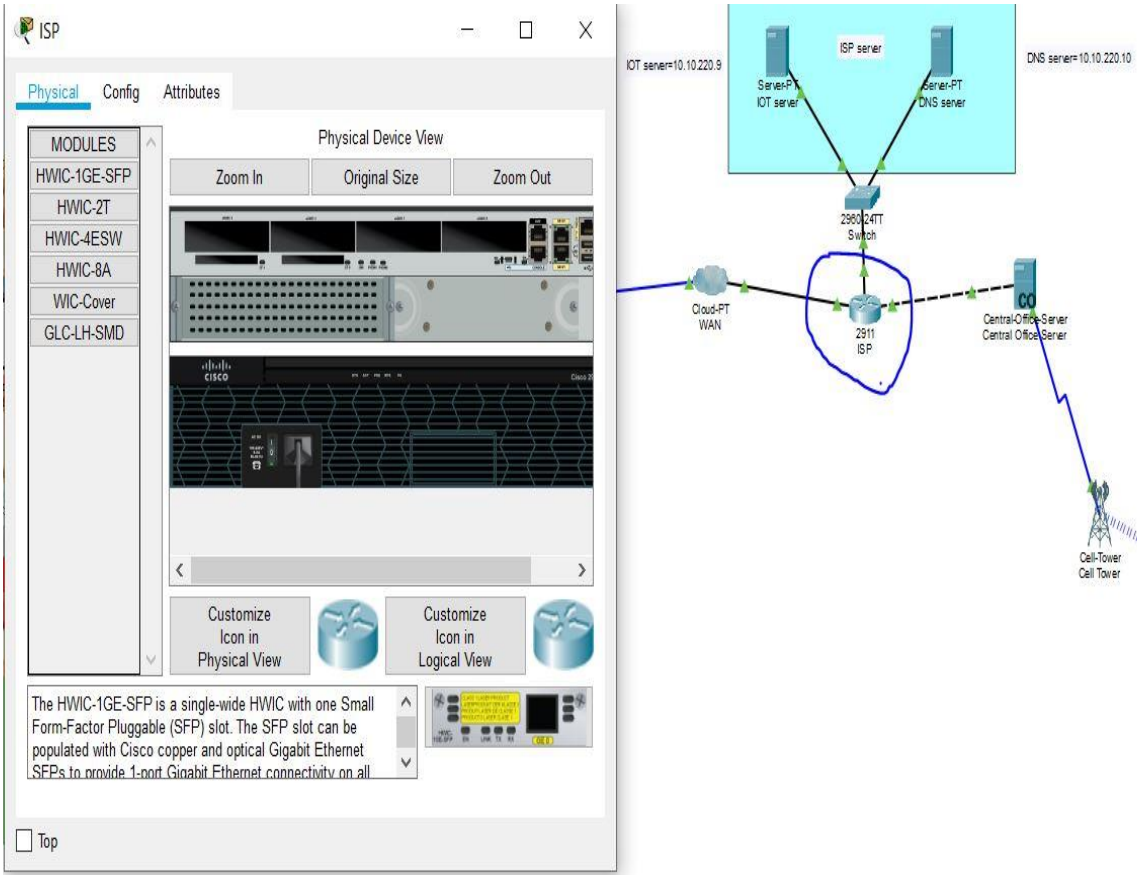

Figure 3.8. Physical View of ISP Router

Assigning hostname and IP address for ISP router

Router>

Router>enable

Router#conf terminal

Router(config)#hostname ISP

ISP(config)#intgigabitEthernet 0/2

ISP(config-if)#ip address 10.10.220.1 255.255.255.0

ISP(config-if)#no shutdown

ISP(config)#intgigabitEthernet 0/0

ISP(config-if)#ip address 209.165.200.225 255.255.255.224

ISP(config-if)#no shutdown

ISP(config)#intgigabitEthernet 0/1

ISP(config-if)#ip address 209.165.201.225 255.255.255.224

ISP(config-if)#no shutdown

Configuring DHCP server for cell and IOE device

ISP(config)#ipdhcp excluded-address 209.165.201.225 209.165.201.230
SP(config)#ipdhcp pool cell
ISP(dhcp-config)#network 209.165.201.225 255.255.255.224
ISP(dhcp-config)#default-router 209.165.201.225
ISP(dhcp-config)#dns-server 10.10.220.10

ISP(config)#ipdhcp excluded-address 209.165.200.225 209.165.200.230
ISP(config)#ipdhcp pool ioe
ISP(dhcp-config)#network 209.165.200.224 255.255.255.224
ISP(dhcp-config)#default-router 209.165.200.225
ISP(dhcp-config)#dns-server 10.10.220.10

-IOE serve: is used to remotely connect the IoT devices on it in order to remotely acess them through a web interface using a computer or a smartphone. In general, all he smart objects registered on the IoE server can be remotely controlled via a web interface hosted on the IoT server. [13].

The IoE server is configured with a static IP address in order for all the smart devices to connect to it utilizing the same IP address. Figure 3.9 show the IP address configuration using Static.

The devices can be accessed using the username and password already created on the IOE server, therefore during the devices registration on the IOE server, the same username and password must be specified with the IOE server IP address. Figure 3.10 show the device registration on the IOE server.

DNS server: is used to enable user to remotely access internet of things server not by using the IP address but the using the domain name of the DNS server that is “iot.org” as shown and Figure 3.11 It is important to configure the DNS server with static IP address as shown in Figure 3.12

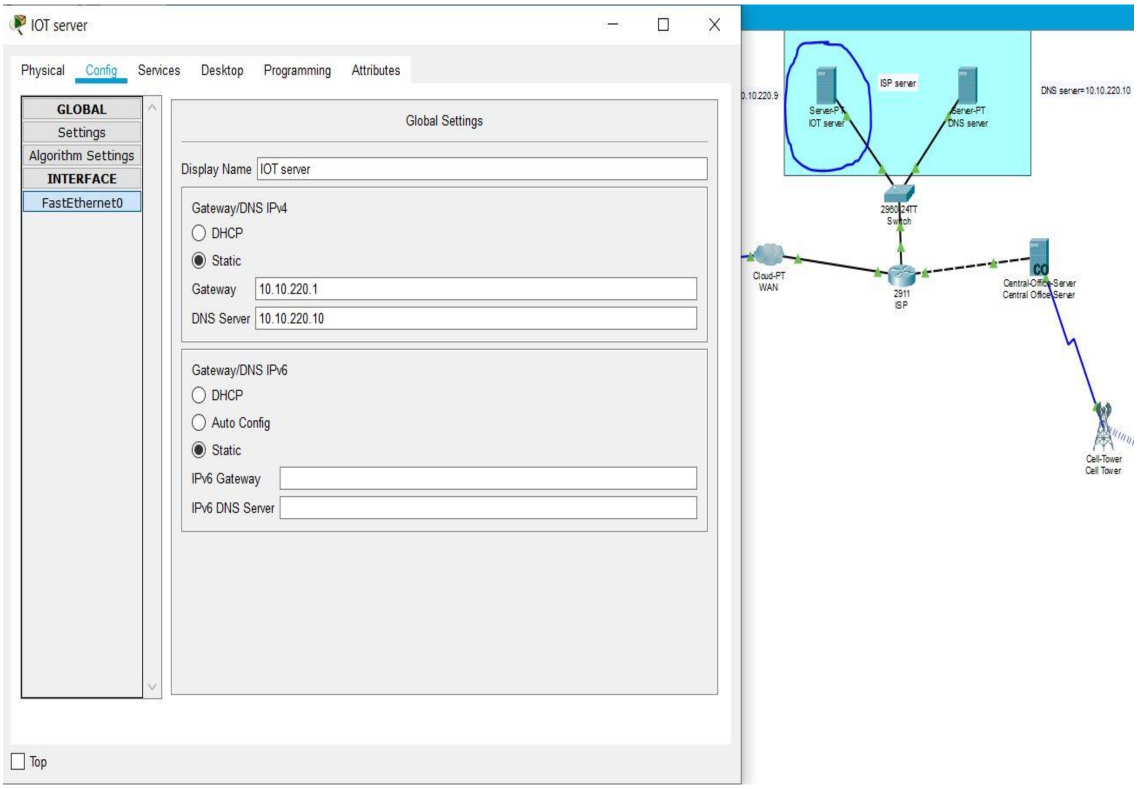

Figure 3.9. IP Address assignment for IoT Server

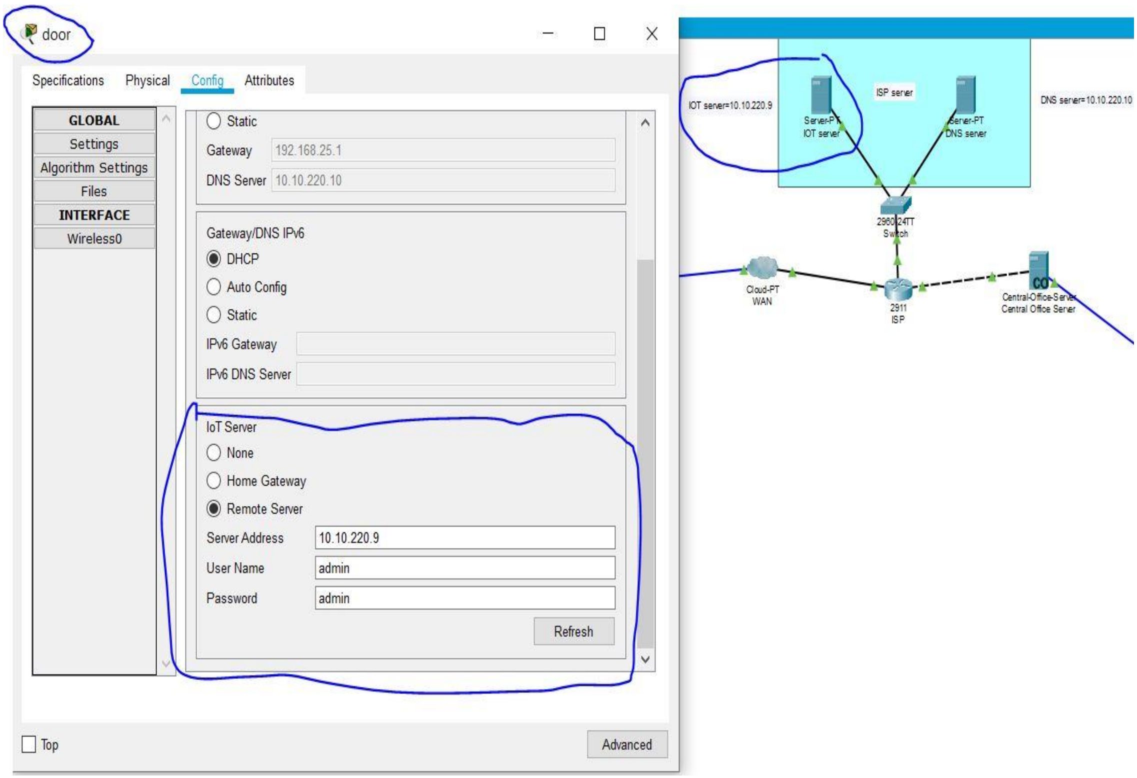

Figure 3.10. Connecting IoT Devices to IoT Server

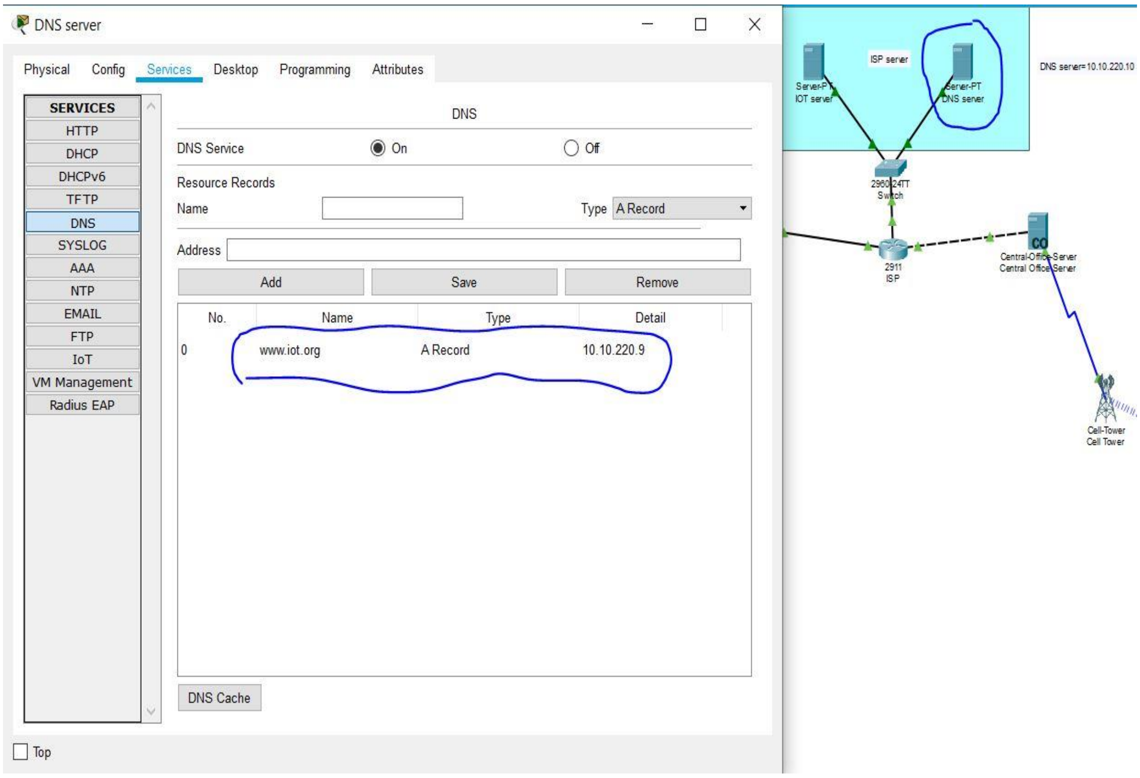

Figure 3.11. Domain Name Configuration

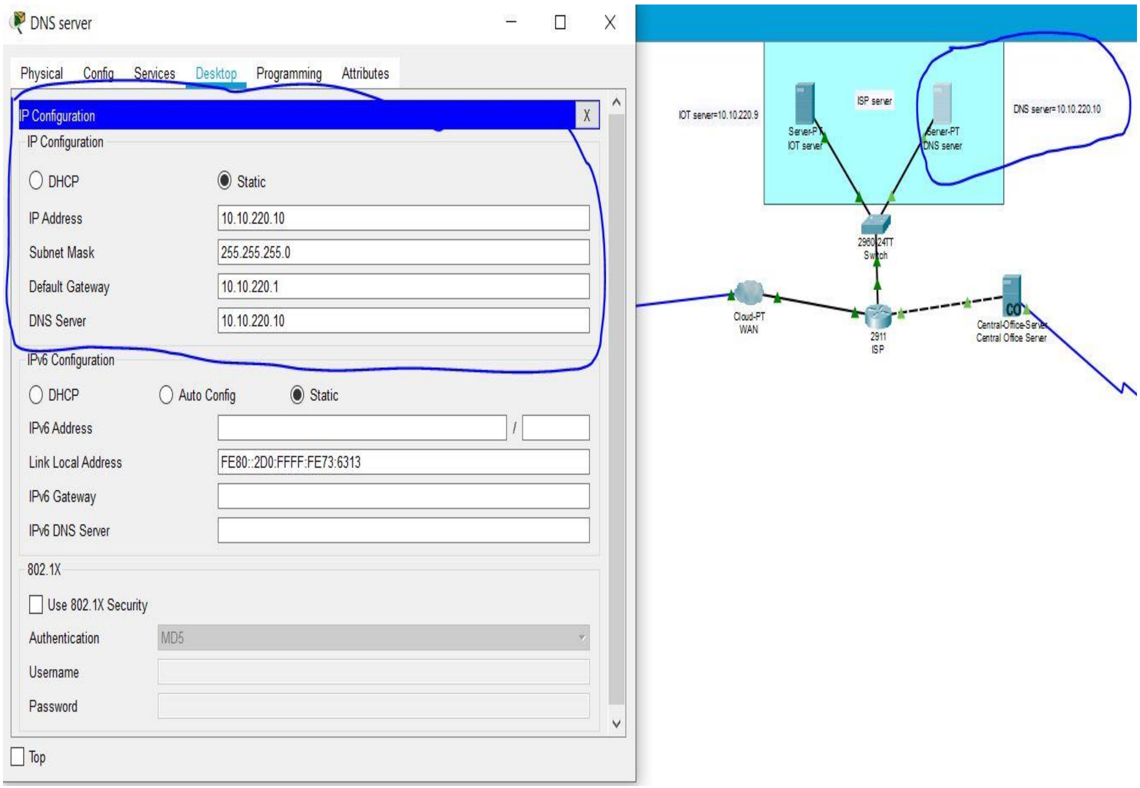

Figure 3.12. IP Address Assignment for DNS Server

IOT cloud (WAN): is used to transfer the collected data by the smart devices from the home to the Iot server in order to be stored. The smart devices get the IP address from the home gateway through the cloud. There is not much configuration in the WAN; we associate the Ethernet interface from router to the coaxial interface to the cable modem as shown in Figure 3.13.

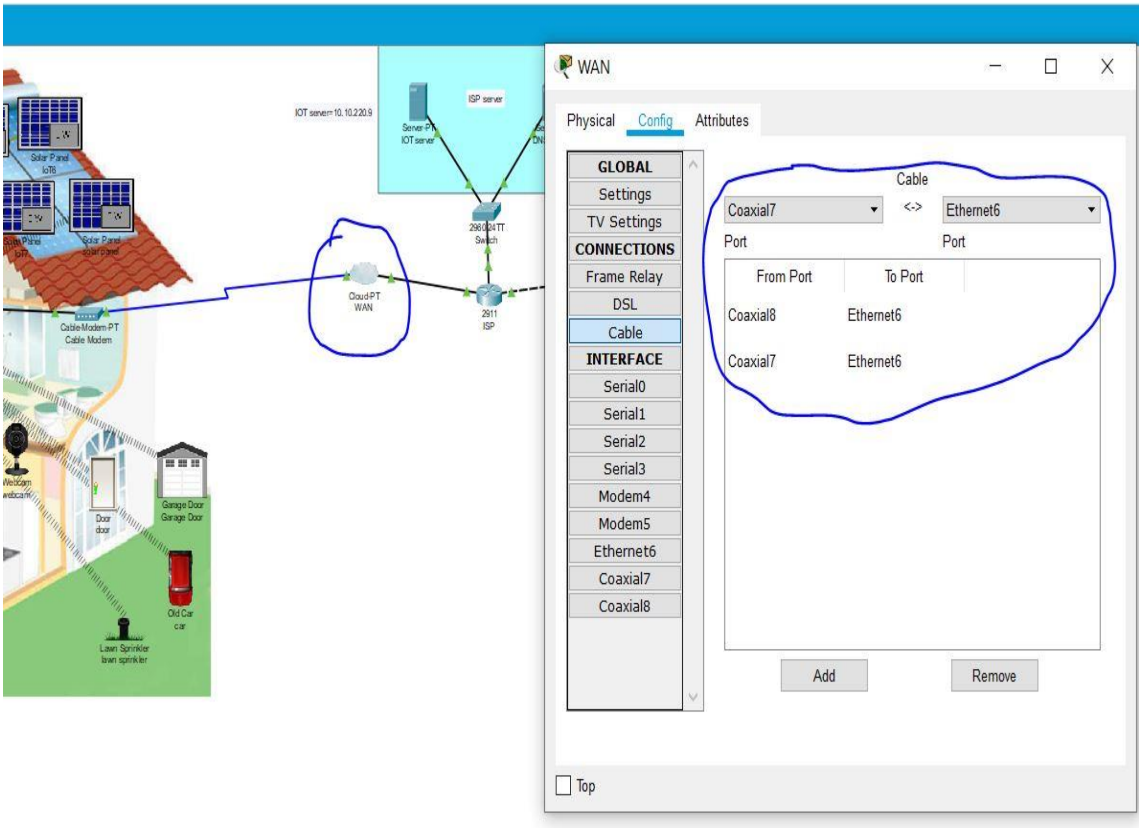

Figure 3.13. WAN Configuration

-Central office server: is used to connect cell tower to ISP router and vice versa for information transferring between them. After configuration of the DHCP server and DNS server on the ISP router, the central office server automatically gets all the IP information from the ISP as presented by Figure 3.14.

Cell tower is used to provide cellular system coverage to the homeowner in order to access and control the home appliance from distance.

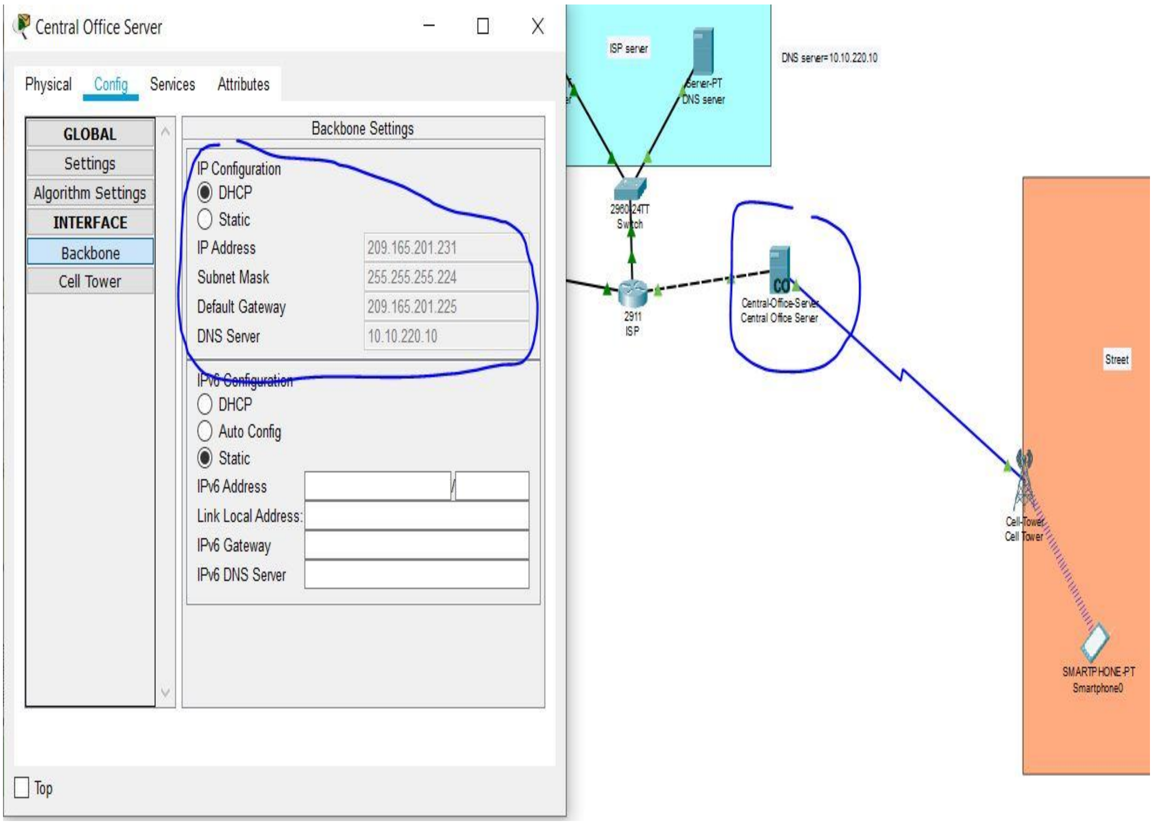

Figure 3.14. Central Office Server

Smart car: the car in the packet I used for carbon dioxide detection around and does not have any other function that is why it is considering as an old car among the IoT devices in the cisco packet tracer. The Figure 3.15 below show the specification of the old car and the function.

But the cisco packet tracer offer the possibility to change the function of devices by writing our own code using java script, python and visual. In the simulation, python language was used to change the function of the old car to a smart car.

The code consists some functionalities to remotely move the car by pressing to different buttons. There are actually for buttons: stop, up, down, left and right. By pressing those buttons with the smart phone, we can move the direction we want. Figure 3.16 show the specification and function of the smart car.

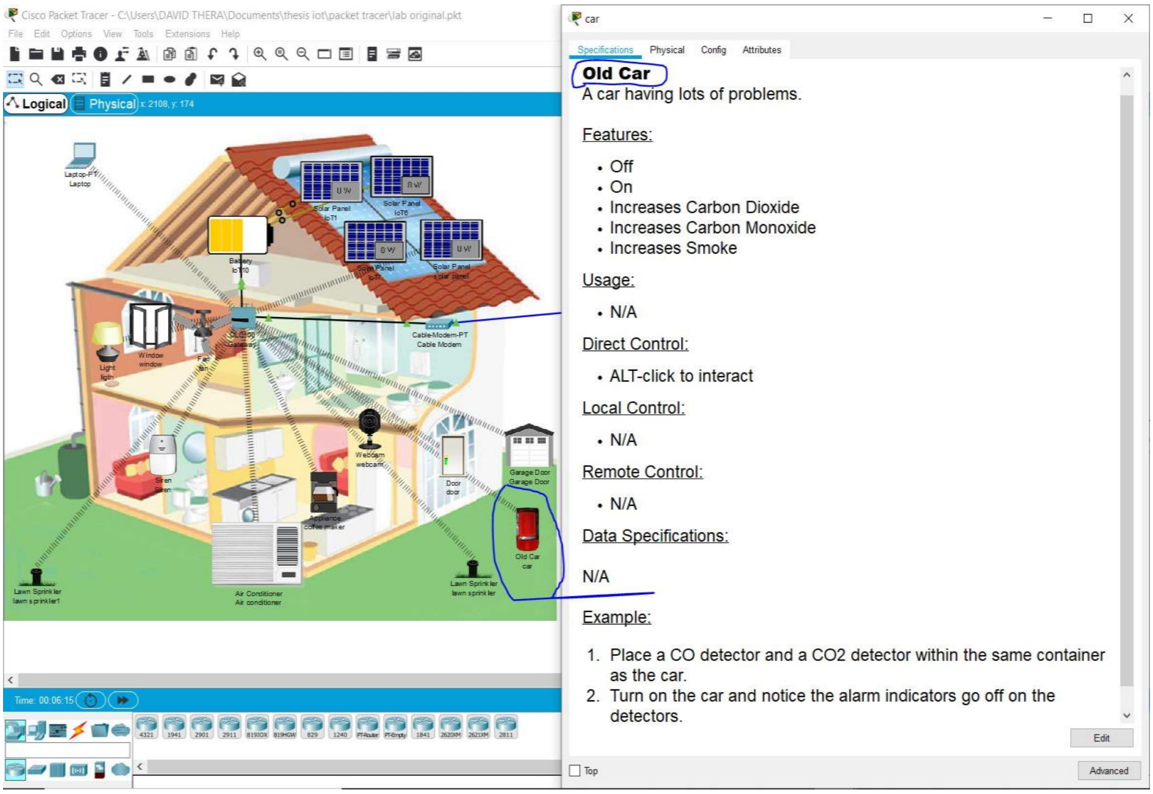

Figure 3.15. Old Car Specifications

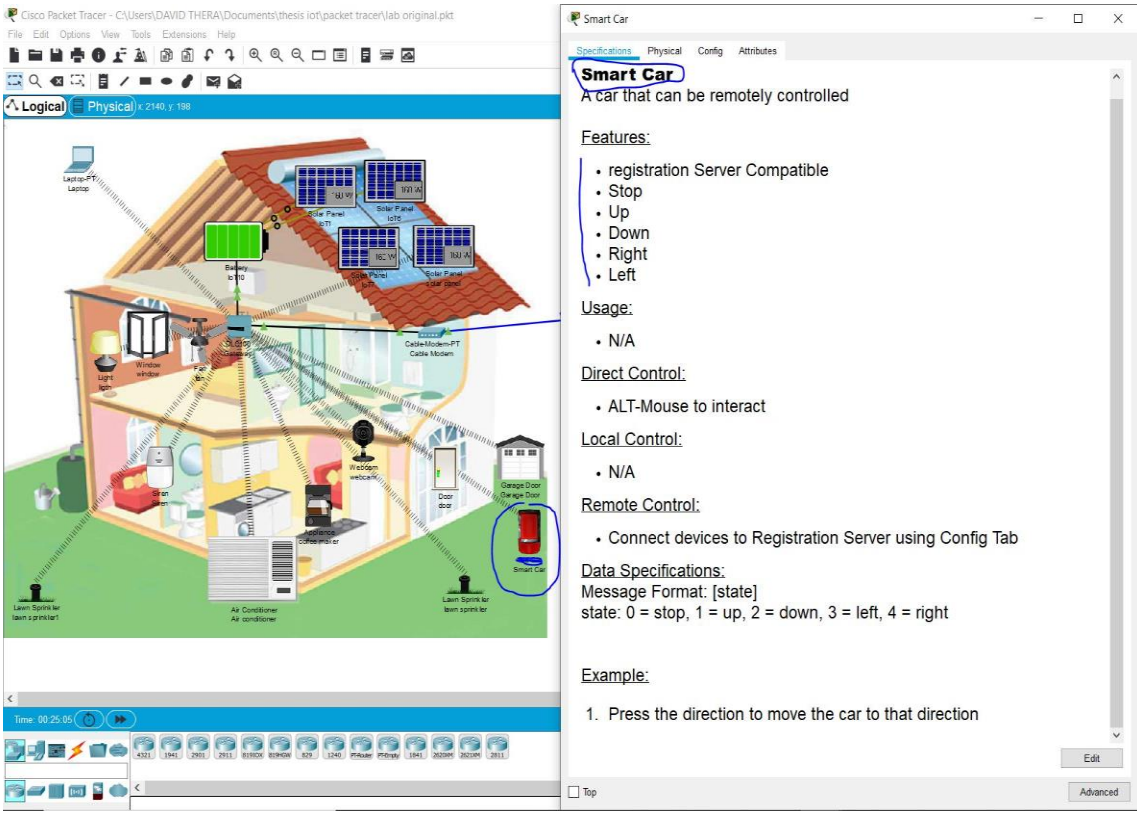

Figure 3.16. Smart Car Specifications

The cable modem: used for connection between home and internet. It provide internet connection.

There is no configuration with this particular devices in the simulation.

Smartphone: is used to remotely access the smart object through a web interface using the URL www.iot.org with an internet connection [13].

The cell phone is connected to the cell tower in order to access the internet connection.

To connect the smartphone to the 3G cell tower, the correct APN (Access Point Name) "ptcell" is configured in the smartphone as shown Figure 22.

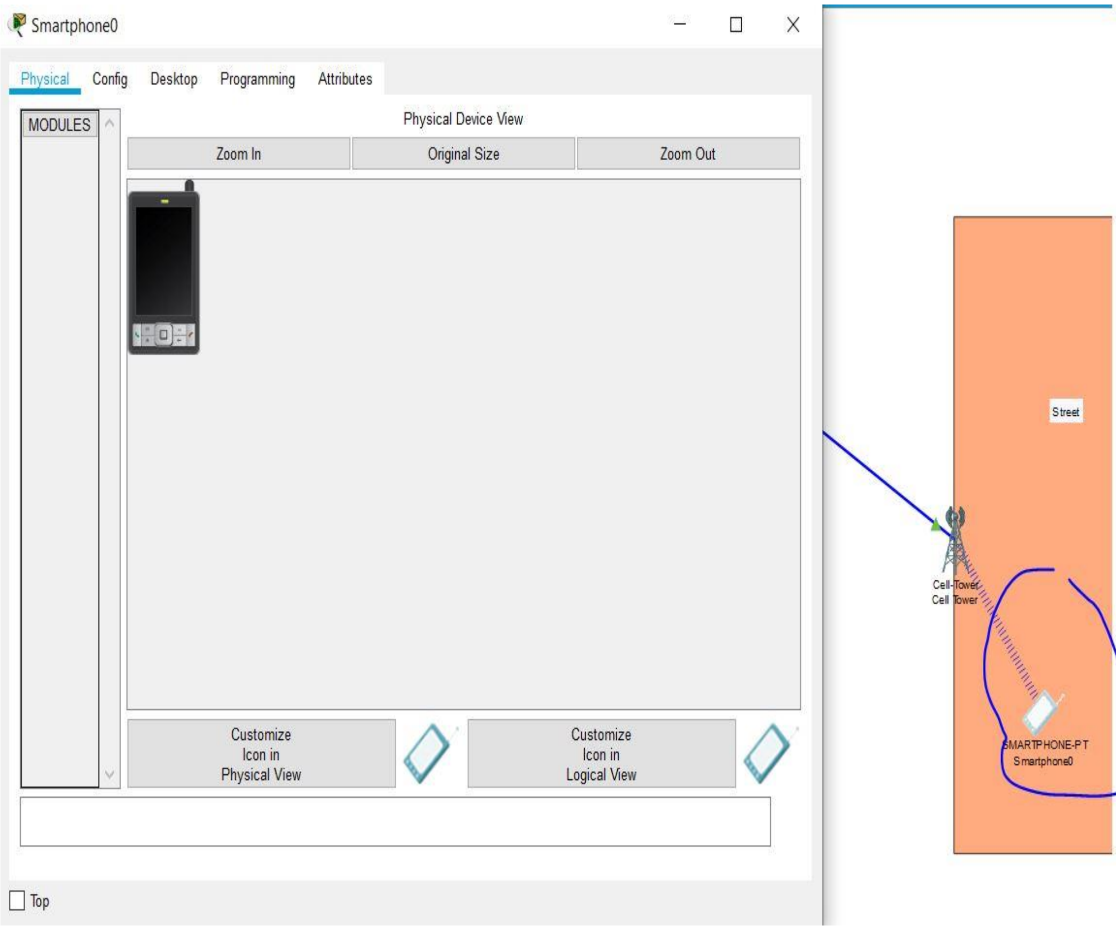

Figure 3.17. Smart Phone Physical View

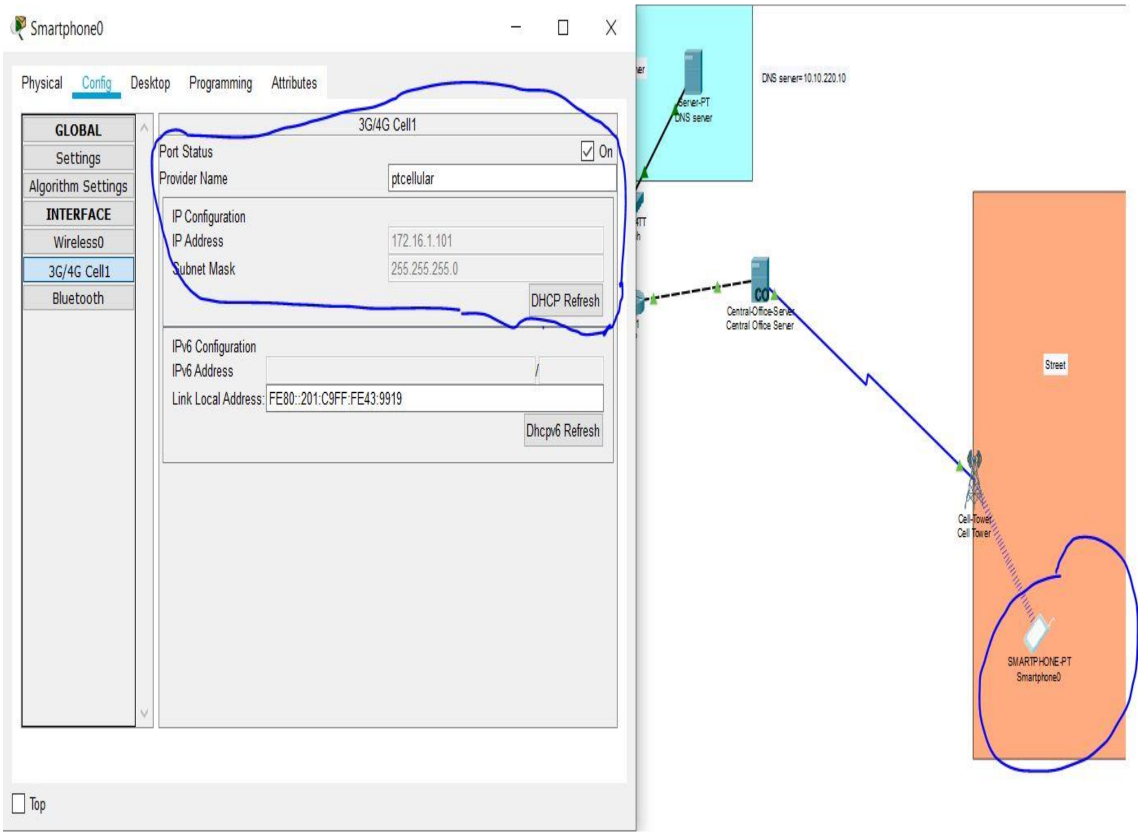

Figure 3.18. Smart Phone Connection to the Cell Tower

3.2.4. Result of implementation:

While all the devices have been configured, they can all be accessed through a web browser of the smartphone with the URL www.iot.org using the correct user name and password. After being connected to the IoT homepage through browser and successfully passing the authentication, the user can then see the list of the connected devices and perform the action he want.

Figure 23 shows the registration server login using the web browser of the smartphone with URL www.iot.org

Figure 24 shows the list of the devices registered on the IoT server.

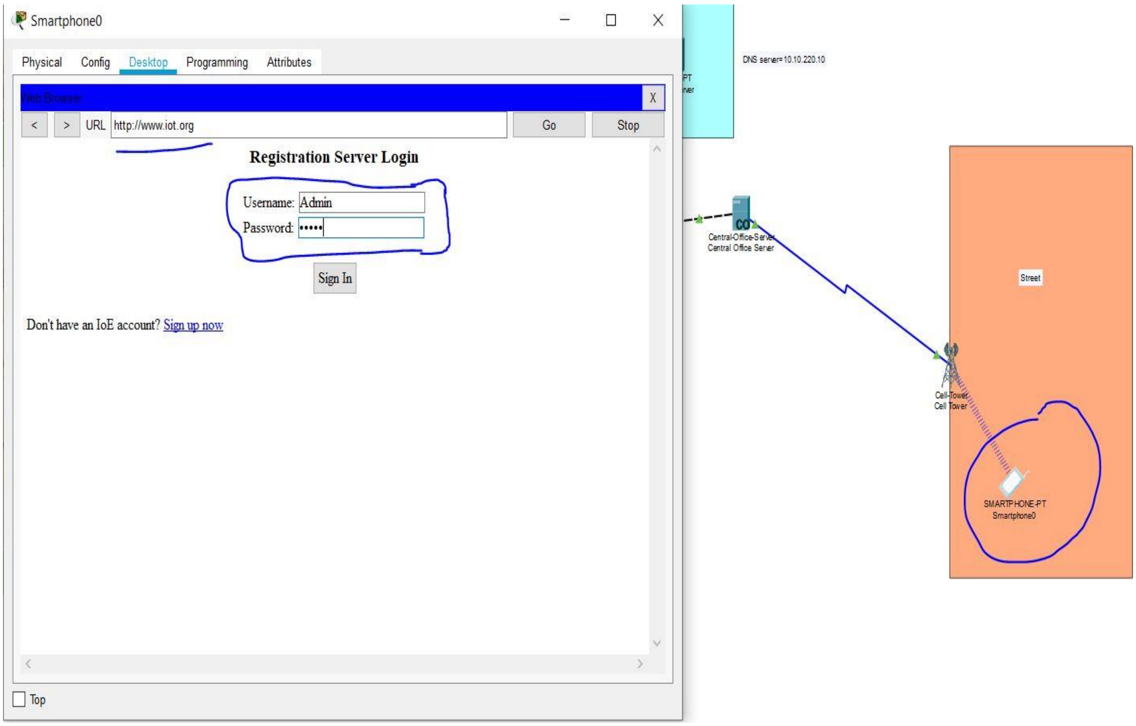

Figure 3.19. Registration Server login

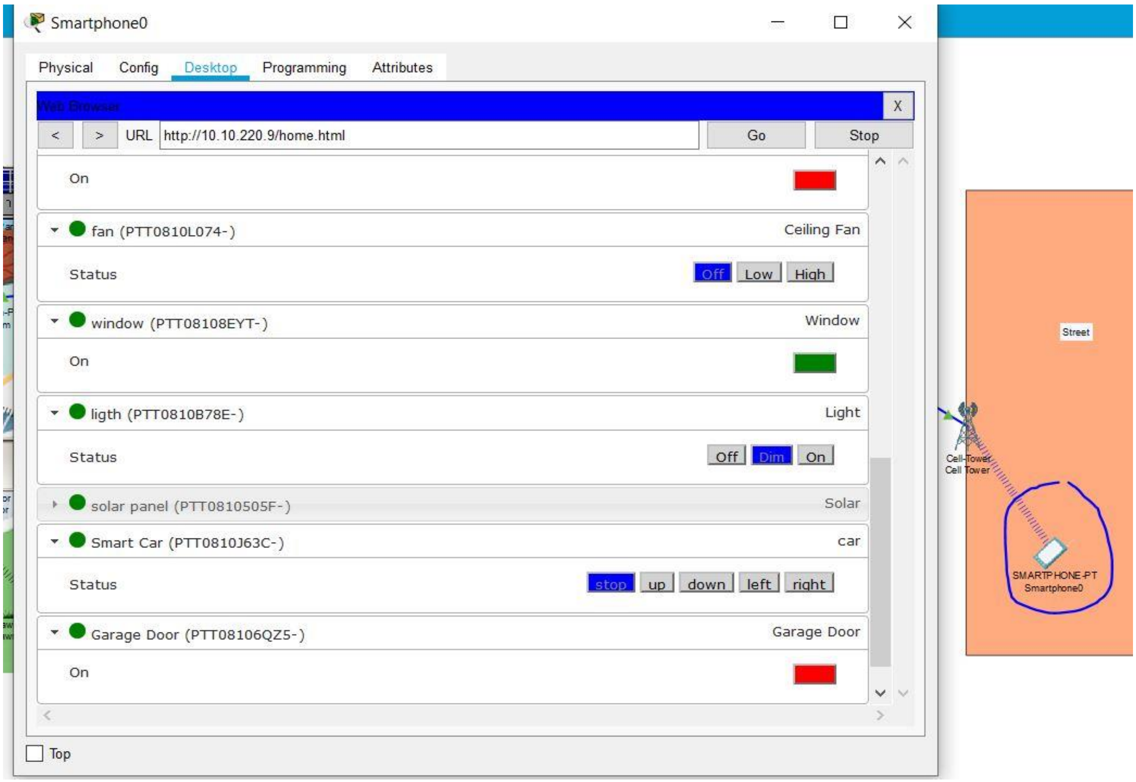

Figure 3.20. IOT Devices Status

CHAPTER 4

CONCLUSION

4.1. Conclusion:

This research work was to simulate the internet of things using a cisco packet tracer. Internet of Things is a new revolutionary and advanced technology, therefore the need to have a virtual practical tool where students can learn and understand this technology was necessary. That is the motivation behind this research.

I choose cisco packet tracer because it offers a simulation environment with devices that look like devices in real life, also within the new version of the packet tracer we can find many internet of things devices, actuator and other sensors, which make the cisco packet tracer the suitable simulator for internet of things.

The ideas was to implement and simulate a very famous internet of things application that is the smart home using cisco packet tracer. The implementation is done using the latest version of the cisco packet tracer (Cisco packet tracer 7.2) because this version included many smart devices used for smart home. Many others network devices are used in order to achieve the simulation, those are gateway, router, cable modem, IoT and DNS servers, Router, switch, cell tower, cloud WAN, central office sever and a smartphone.

The home gateway is used in order to connect different smart devices on it and IP address distribution to those smart devices via wireless network. The IoT server and the smartphone play a very important role in the simulation because, they permit to remotely control the Iot devices via internet. The IoT server is used for smart devices registration while the smartphone is used remotely access the smart devices registered on the IoT server.

The utilizing of various internet of things devices and network devices included in cisco packet tracer made the simulation easy and also more IoT devices will be included in the upcoming version of the cisco packet tracer, so more complex IoT simulation can be made.

4.2. Future Research

There are many Simulator used to simulate IoT technology. Therefore, future research can be the comparison between cisco packet tracer with others IoT simulations such as NetSim or NodeRed etc. This thesis work was only focused on how to simulating IoT with cisco packet tracer therefore, any research about others IoT simulators was made in this study.
Since it is expected from cisco to release new version of packet tracer with more IoT devices, simulation of more complex IoT applications can be made as future research.

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APPENDIX A

PYTHON CODE FOR SMART CAR

```
from gpio import *

from time import *

from physical import *

from ioeclient import *

from environment import *


state = 0;  # 0 stop, 1 up, 2 down, 3 left, 4 right

lastTimeInSeconds = 0

def main():

    setup()

    while True:

        loop()

def setup():

    IoEClient.setup({

        "type": "car",

        "states": [

        {
```

```
            "name": "Status",
            "type": "options",
            "options": {
                "0": "stop",
                "1": "up",
                "2": "down",
                "3": "left",
                "4": "right"
            },
            "controllable": True
        }
        ]
    })
    IoEClient.onInputReceive(onInputReceiveDone)
    global state
    add_event_detect(0, detect)
    state = restoreProperty("state", 0)
    setState(state)
def detect():
    processData(customRead(0), False)
```

```
def onInputReceiveDone(analogInput):

   processData(analogInput, True)

def restoreProperty(propertyName, defaultValue):

    value = getDeviceProperty(getName(), propertyName)

    if  not (value is "" or value is None):

        if  type(defaultValue) is int :

            value = int(value)

        setDeviceProperty(getName(), propertyName, value)

        return value

    return defaultValue

def mouseEvent(pressed, x, y, firstPress):

    global state

    if firstPress:

        setState(state+1)

def loop():

    updateEnvironment()

 sleep(1)



def processData(data, bIsRemote):

    if  len(data) <= 0 :
```

```
        return
    setState(int(data))
def setState(newState):
    global state
    if newState >= 5 :
        newState = 0
    state = newState
    analogWrite(A1, state)
    customWrite(0, state)
    IoEClient.reportStates(state)
    setDeviceProperty(getName(), "state", state)
def updateEnvironment():
    global VOLUME_AT_RATE
    global ENVIRONMENT_IMPACT_DIM
    volumeRatio = float(VOLUME_AT_RATE) / Environment.getVolume()
    print("volume ratios is " + str(volumeRatio))
    print("lalalala " + str(ENVIRONMENT_IMPACT_DIM*2*volumeRatio))
    if  state is 0 :
        Environment.setContribution("stop...", 0,0, False)
    elif  state is 1 :
```

```
        Environment.setContribution("up...", 0, -20, True)

        moveBy(0,-5)

        print("up is pushed..")

    elif  state is 2 :

        Environment.setContribution("down..", -20,0, True)

        moveBy(0,5)

        print("down is pushed..")

    elif  state is 3 :

        Environment.setContribution("left..", 0,20, True)

        moveBy(-5,0)

        print("left is pushed..")

    elif  state is 4 :

        Environment.setContribution("right...", 20,0, True)

        moveBy(5,0)

        print("right is pushed..")

if __name__ == "__main__":

    main()
```

https://github.com/davidthera/iot-simulation-with-cisco-packet-tracer