1. ABSTRACT

Internet of Things Simulation Using CISCO Packet Tracer

The term IoT (Internet of Things) has become extremely important in our life nowadays. This technology is being used widely in various fields. In order to learn and understand how this technology works, this project simulates a Home Automation System that allows us to simulate, build and manage a real life system to better comprehend and appreciate the philosophy behind IoT networks.

Home Automation is a wireless home automation system that is supposed to be implemented in existing home environments, without any changes in the infrastructure. Home Automation lets the user control the home appliances remotely from his or her computer and assignations that should happen depending on time or other sensor readings such as light, temperature or sound from any device in the Home network.

In this project, we present a Home Automation system(HAS) using Cisco Packet Tracer that employs the integration of cloud networking, wireless communication, to provide the user with remote control of various lights, fans, and appliances within their home and storing the data in the cloud. The system will automatically change on the basis of sensors' data. This system is designed to be low cost and expandable allowing a variety of devices to be controlled. Certain actions are also programmed into the IoT devices that respond to the changing environment of the simulated house.

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2. INTRODUCTION

With the advancement of technology, life is getting simpler and easier in all aspects. Today manual systems are constantly being replaced by not only digital but digitally automated systems, as they provide far more convenience, stability and save time and effort. The rapid increase in the number of users of the internet over the past decade has made the Internet a part and parcel of life, and IoT is the one of latest emerging internet technologies. The Internet of things is a growing network of everyday objects- from industrial machines to consumer goods that can share information and complete tasks while you are busy with other activities.

Wireless Home Automation system(WHAS) using IoT is a system that uses computers or mobile devices to control basic home functions and features automatically through the internet from anywhere around the world, an automated home is sometimes called a smart home. It is meant to save electric power and human energy. The home automation system differs from other systems by allowing the user to operate the system from anywhere around the world through internet connection.

Homes of the 21st century are already on the path to become increasingly self-controlled and automated due to the convenience and security it provides, especially when employed in a private home. A home automation system is a means that shall allow users to control electric appliances of varying kinds. Many existing, well established home automation systems are based on wired communication. This does not pose a problem if the system is planned well in advance and installed during the physical construction of the building but for already existing buildings the implementation cost is very high. In contrast, Wireless systems can be of great help for automation systems. With the advancement of wireless technologies such as Wi-Fi, cloud networks in the recent past, wireless systems are used every day and everywhere and shall drive the progress of the future.

2.2 What is Internet of Things (IoT)?

Internet of things or internet of everything refers to the idea of things (objects) that are readable, recognizable, locatable and addressable through information sensing devices (sensors) and controllable via the internet.

The 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.

The Internet of Things is a new disruptive technology where any object becomes a smart object when they communicate information about themselves without human intervention. It is expected to make a huge change in our lives and help us to perform our tasks and duties in a better way.

2.3 Real World Implementation of the Project:

Smart Homes: They refer to a home equipped with smart appliances, fridge, air conditions, light, camera, fan, smart thermostats, door locks etc. that can be remotely controlled and managed through the internet using a smartphone or a computer. The possibility to manage the home equipment from a distance offers homeowner security, comfort and convenience. Smart homes also help in saving energy, avoiding accidents and improving security. The environment in the house can also be maintained automatically to the owner's liking.

The fundamentals of the project can also be the basis of other implementations of IoT projects.

- Industrial Internet of Things (IIoT) - Using IoT to monitor and control the process of the factory and to predict malfunctions before they occur. This will improve safety along with the productivity of the factory.
- Internet of Medical Things (IoMT) - It would allow doctors to monitor and provide healthcare to patients wherever they may be.
- Smart Cities - The city government can use IoT to control and monitor the infrastructure and transportation of the city and also keep a track of the air and water quality of the city.
- Smart Cars - A smart car is a car that can be remotely controlled by a user and can be used to drive the car from a distance and observe the attributes of the vehicle.

2.4 Cisco Packet Tracer Overview

Cisco packet tracer is a powerful virtual network simulation tool used to learn and understand different concepts in computer networks. The tool is developed by Cisco in order to allow students or users to get practical networking technology knowledge. It allows us to simulate a network by using virtual devices such as hubs, routers, switches etc. without having any physical network.

The good thing about this particular simulation tool is that it provides an environment where devices resemble devices in the real world. This is very important because it gives the user the possibility to be familiar with devices before working with the real equipment. It allows us to configure devices using two options: config tab or CLI tab (command line interface). With CLI, we configure devices using the cisco command line. It's advantage is that the commands we use to configure devices virtually are the same command we use with the real devices. The config tab does not require any Cisco command knowledge as its done with a GUI and can be time saving for the user.

The latest versions of cisco packet tracer include new features that can help us to perform IoT simulations. Those new features are smart devices, sensors, actuators and microcontrollers. Some of those smart devices included are smart windows, smart fan, smart light, and alarm siren. We can also find some sensors such as water level, temperature, humidity, carbon monoxide and carbon dioxide.

One most important thing with the new version is that all the devices can be programmable using different programming languages such as python, javascript and blocky. In addition, they can all be connected through wired cable or through wireless.

The internet of things devices in the Cisco Packet tracer can be used to build and simulate different internet of things applications such as smart home, smart industry, smart city etc. The benefit of using cisco packet tracer is that the user can interact with the devices the same way they do in the real devices. In addition, with its multi user functionality, multiple users can work together to build a virtual network through a real network.

3. REQUIREMENT ANALYSIS

3.1 Hardware Requirements:

Processor : 2.4 GHz Clock Speed (minimum quad cores)

RAM : 4 GB

Hard Disk : 1 GB (Minimum free space)

3.2 Software Requirements:

Operating System : Windows 10

Software Tool : Cisco Packet Tracer 8.0.1

3.3 The Devices Simulated using Packet Tracer:

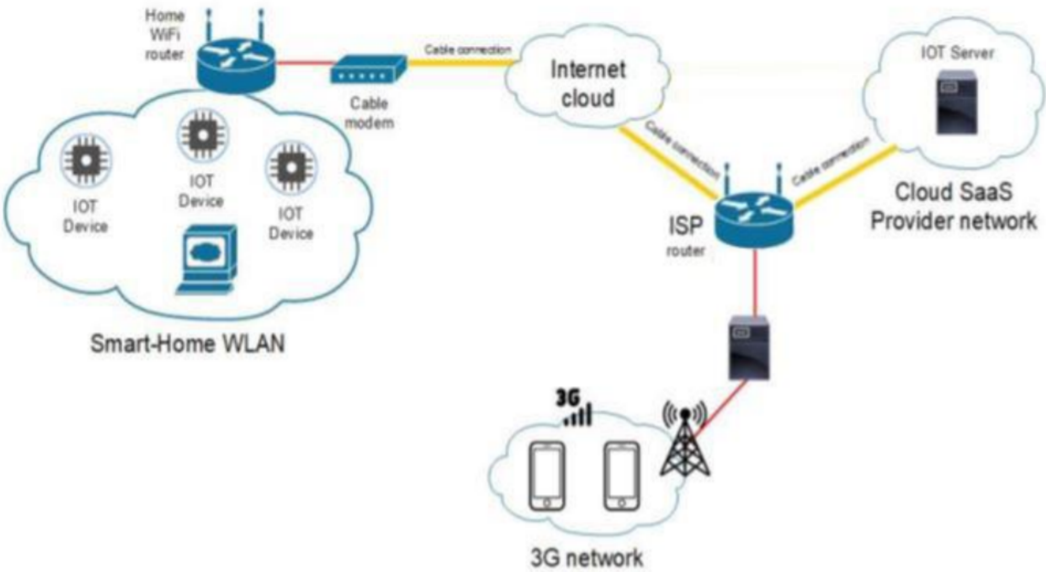
No.	Devices	Function
1	Router (2911) / ISP	Used to connect cellular network to home
2	Cable modem	Used for home gateway to cloud
3	Home gateway	Used for smart devices registration
4	IoT server	Used to control smart devices registered on it
5	DNS server	Used to access smart devices by domain name
6	Central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

12	Smart door	Used to lock and unlock the door from distance
13	Smart windows	Used to control the windows from distance
14	Smart siren	Used to make sound if anything happens at home
15	Motion detector	Used to detect motion
16	Air conditioner	Used for home cooling
17	Lawn sprinkler	Used to sprinkle the garden
18	Old car	Used in create smoke and CO
19	Garage Door	Used to control the garage door
20	Solar panel	Used to provide energy to the home
21	Battery	Used with solar panels to provide energy
22	Laptop	A laptop used to control the IoT devices
23	Coffee maker	Used to control the coffee machine
24	CO Detector	Detects the level of Carbon Monoxide in the air
25	Furnace	Used to heat the house
26	Thermostat	Used to get the temperature in the house
27	Water Level Monitor	Measure the water level in the garden
28	Humidity Monitor	Measure the humidity in the house
29	Humidifier	Increase the humidity in the house

The user must use the latest version of Cisco Packet Tracer (v 8.0.1) that contains all these required devices.

4. ARCHITECTURE AND DESIGN

4.1 Basic Architecture of the Design:



The network topology used for the implementation of the smart home is represented in the figure above. The implementation consists of four parts: the smart home, internet cloud, IoT server and 3G network.

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 concerns the IoT (internet of things) server that registers all the devices connected to it to provide more IoT 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.

4.2 Algorithm:

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 the workspace using a wireless connection.

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

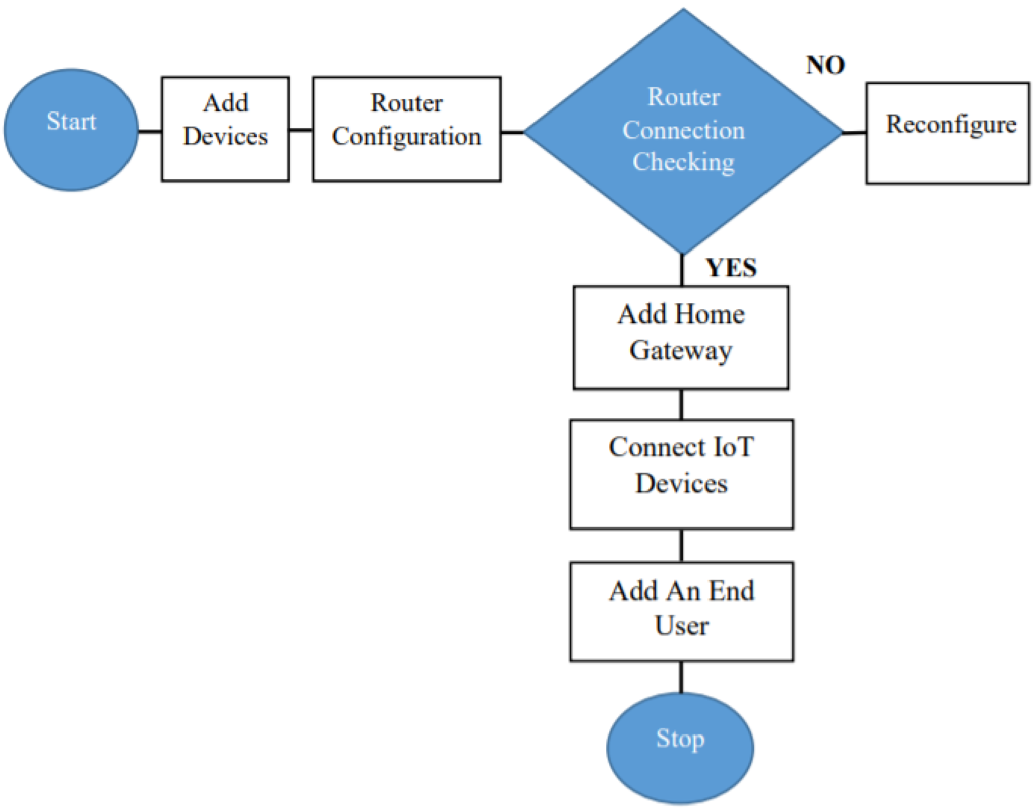
Step 6: Add Home Gateway to the Network.

Step 7: Connect smart Devices to the Wireless Network.

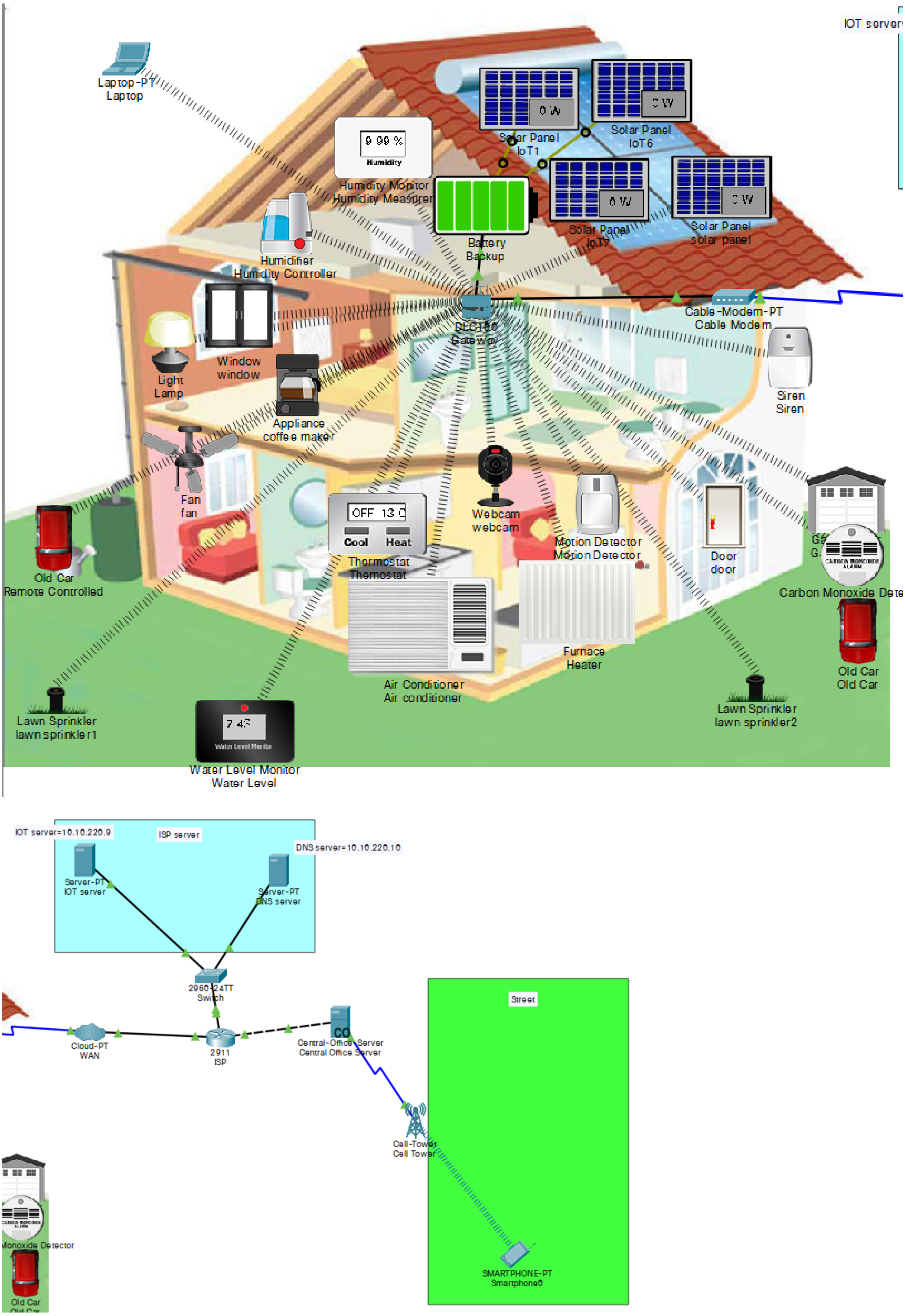
Step 8: Add End User Device to the Network

Step 9: Stop

4.3 FlowChart:



4.4 The Final Configuration:

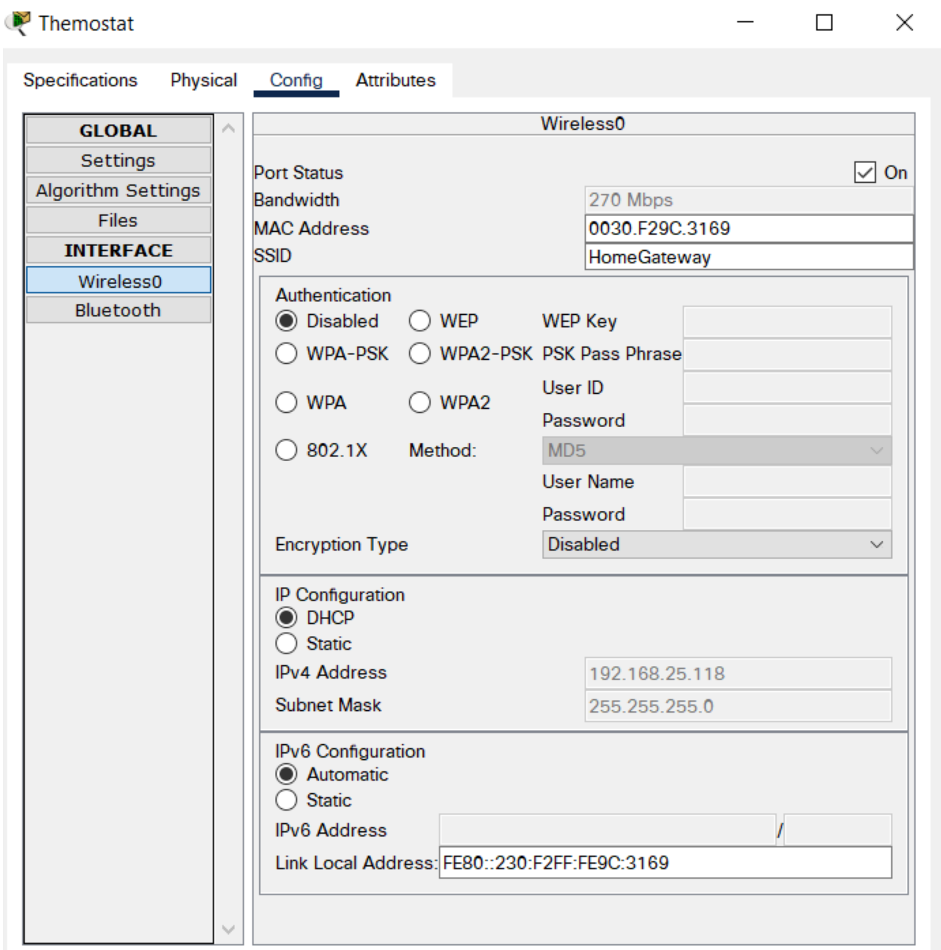


5. IMPLEMENTATION

5.1 THE HOME GATEWAY is used for assigning IP addresses to smart devices and for smart device registration. The home gateway gets the IP address from the ISP Router automatically after that the connection to the cloud WAN is established. Also all the smart objects connected to the home gateway get an IP address from the ISP router automatically via the cloud (WAN). The cable modem is used to connect the home gateway to the cloud.

The home gateway provides a different programming environment to the devices that are java script, python, and visual basic.

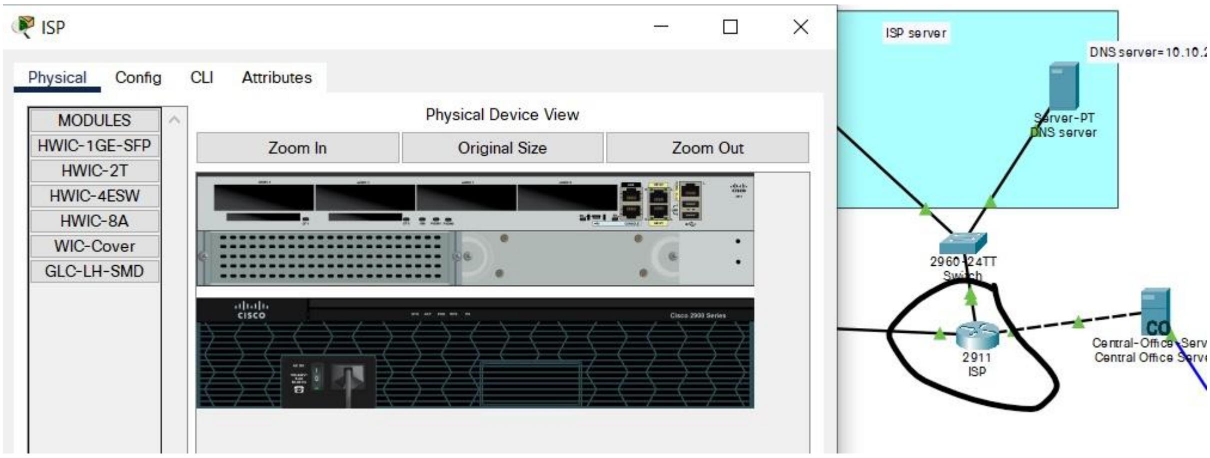
There are four Ethernet ports in the home gateway plus a wireless access point with the SSID “home gateway”. We can configure WEP / WPA –PSK/ WPA2 protocols in the home gateway for wireless connection authentication. In order to connect the devices to the home gateway, we must select wireless since the devices will be connected using wireless connection, then we specify the SSID of the home gateway in the devices.



The above figure is the smart light configuration for the home gateway. The authentication is disabled to just to keep the configuration simple. So we repeated this configuration on all the devices.

5.2 THE ISP ROUTER (internet service provider) is used to connect all the network interfaces to each other, the DHCP server is configured on it in order to assign IP addresses to every connected device dynamically, whether they are smart devices or not, in order to simulate the internet connectivity.

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



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

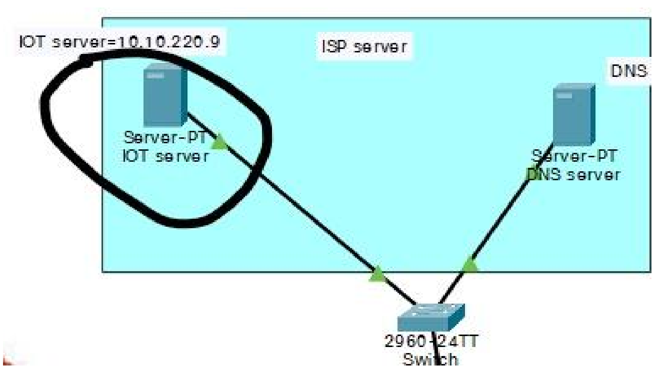
ISP(dhcp-config)#network 209.165.200.224 255.255.255.224

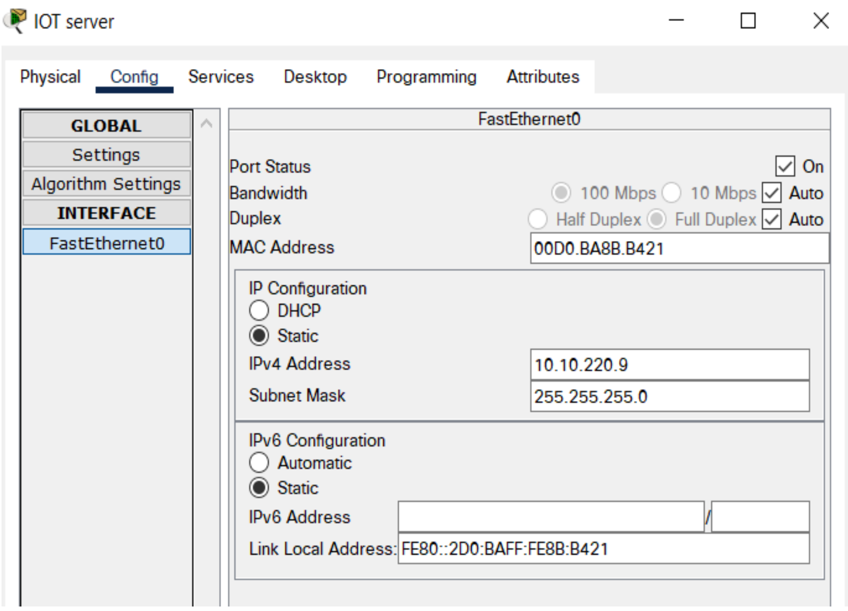
ISP(dhcp-config)#default-router 209.165.200.225

ISP(dhcp-config)#dns-server 10.10.220.10

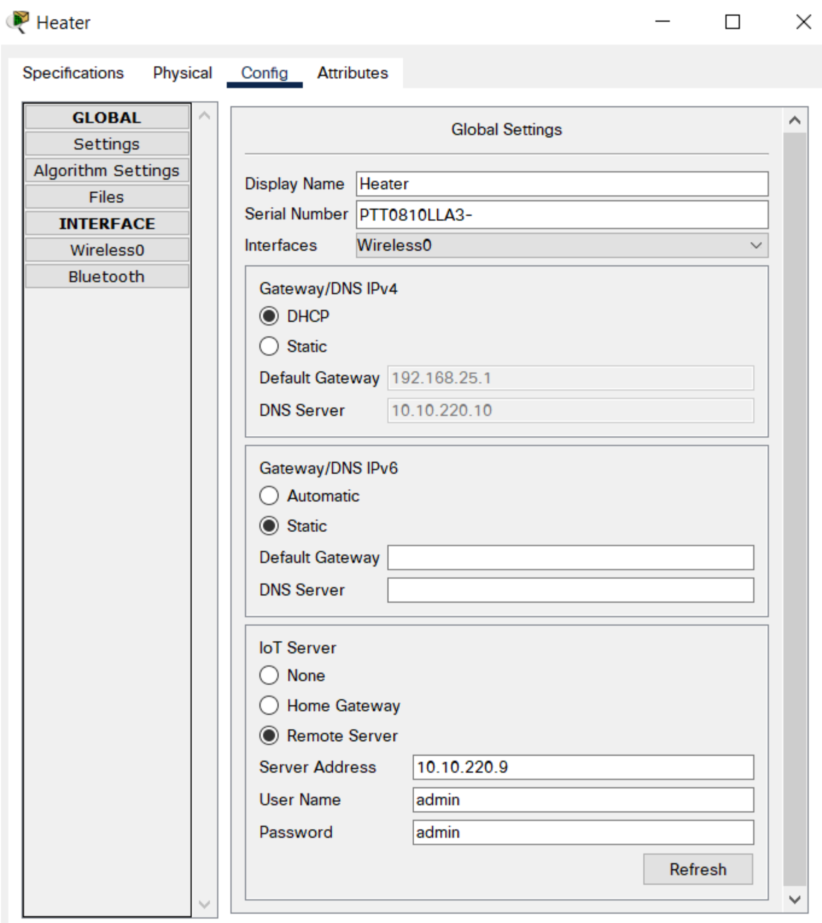
5.3 THE IOE SERVER is used to remotely connect the IoT devices on it in order to remotely access them through a web interface using a computer or a smartphone. In general, all smart objects registered on the IoE server can be remotely controlled via a web interface hosted on the IoT server.

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. The figures below display that.

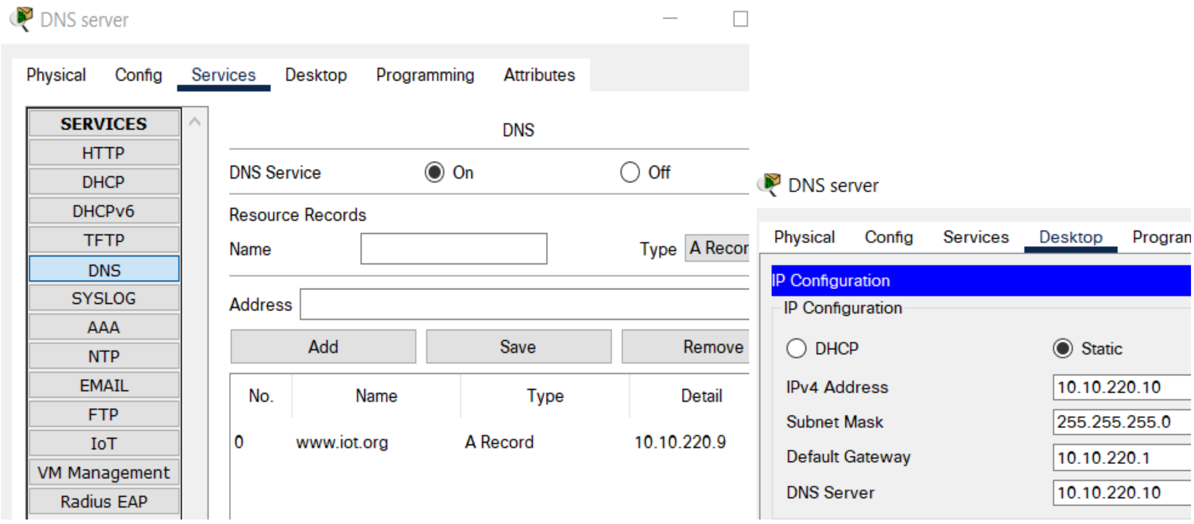




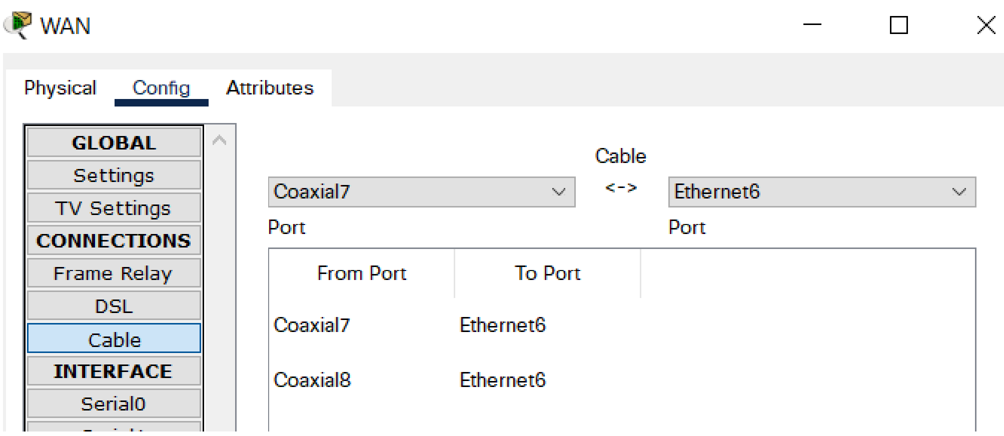
The devices can be accessed using the username and password already created on the IOE server, therefore during the device's registration on the IOE server, the same username and password must be specified with the IOE server IP address. The device registration on the IOE server is shown below.



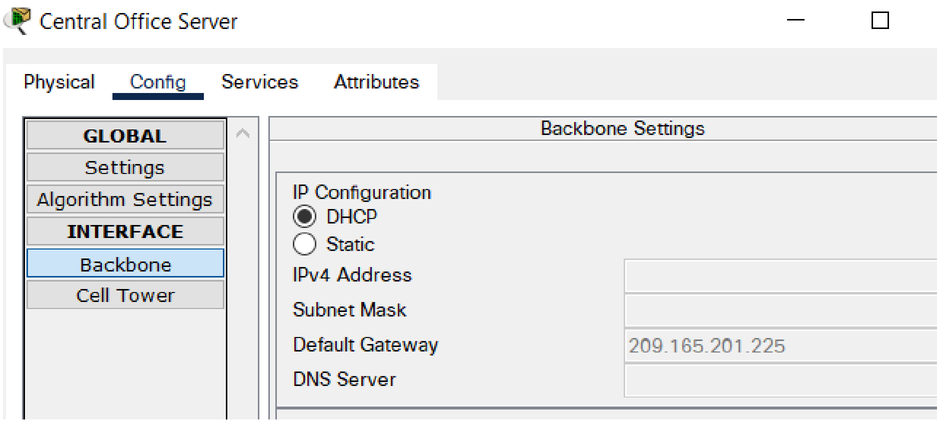
5.4 THE DNS SERVER is used to enable the user to remotely access the internet of things server not by using the IP address but the using the domain name of the DNS server that is "iot.org" as shown below. It is important to configure the DNS server with a static IP address as shown in the figure below.



5.5 THE 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 the router to the coaxial interface to the cable modem as shown in the figure.



5.6 The CENTRAL OFFICE SERVER is used to connect the cell tower to the ISP router and vice versa for information transfer 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 the figure below.



5.7 THE CELL TOWER is used to provide cellular system coverage to the homeowner in order to access and control the home appliance from a distance.

5.8 THE SMART CAR is the car that does not have any other function that is why it is considered as an old car among the IoT devices in the cisco packet tracer. But in this simulation, the Python language was used to change the function of the old car to a smart car. The code consists of some functionalities to remotely move the car by pressing different buttons. There are actually four buttons: stop, up, down, left and right. By pressing those buttons with the smartphone, we can move the direction we want. The code is given below.

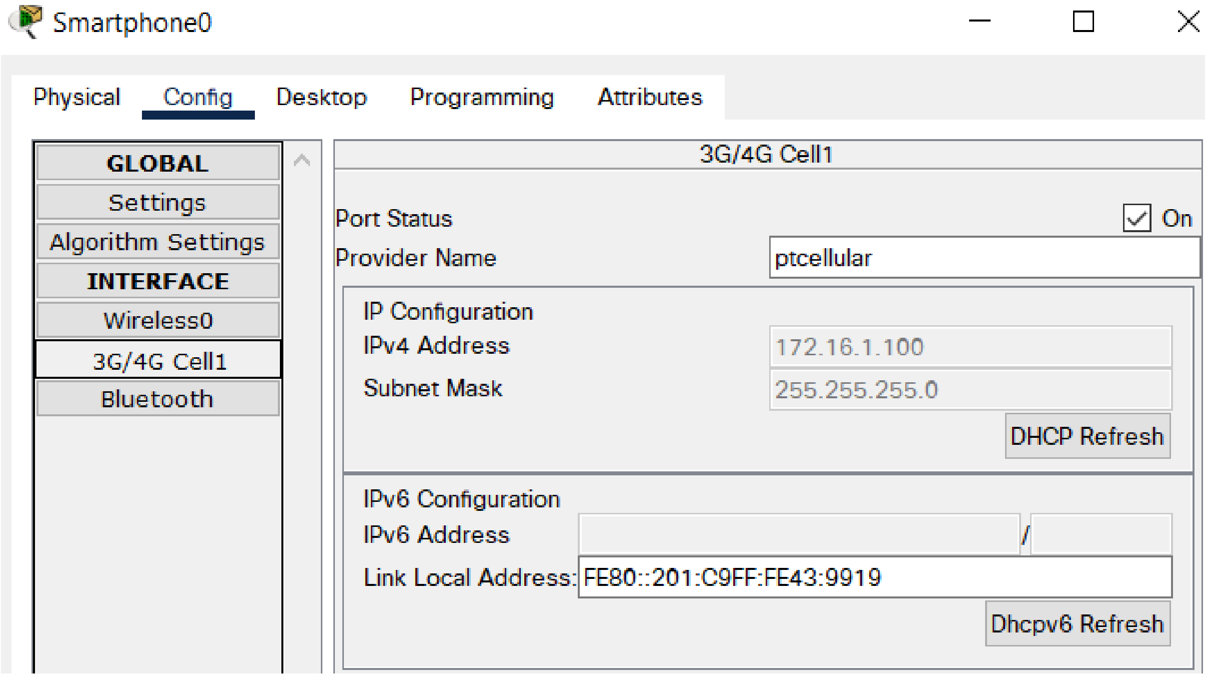
```
from gpio import *
from time import *
from physical import *
from ioeclient import *
from environment import *
state = 0; # 0 stop, 1 up, 2 down, 3 left, 4 right
lastTimeInSeconds = 0
def main():
    setup()
     while True:
         loop()
def setup():
    IoEClient.setup({ "type": "car", "states": [
        {"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)
```

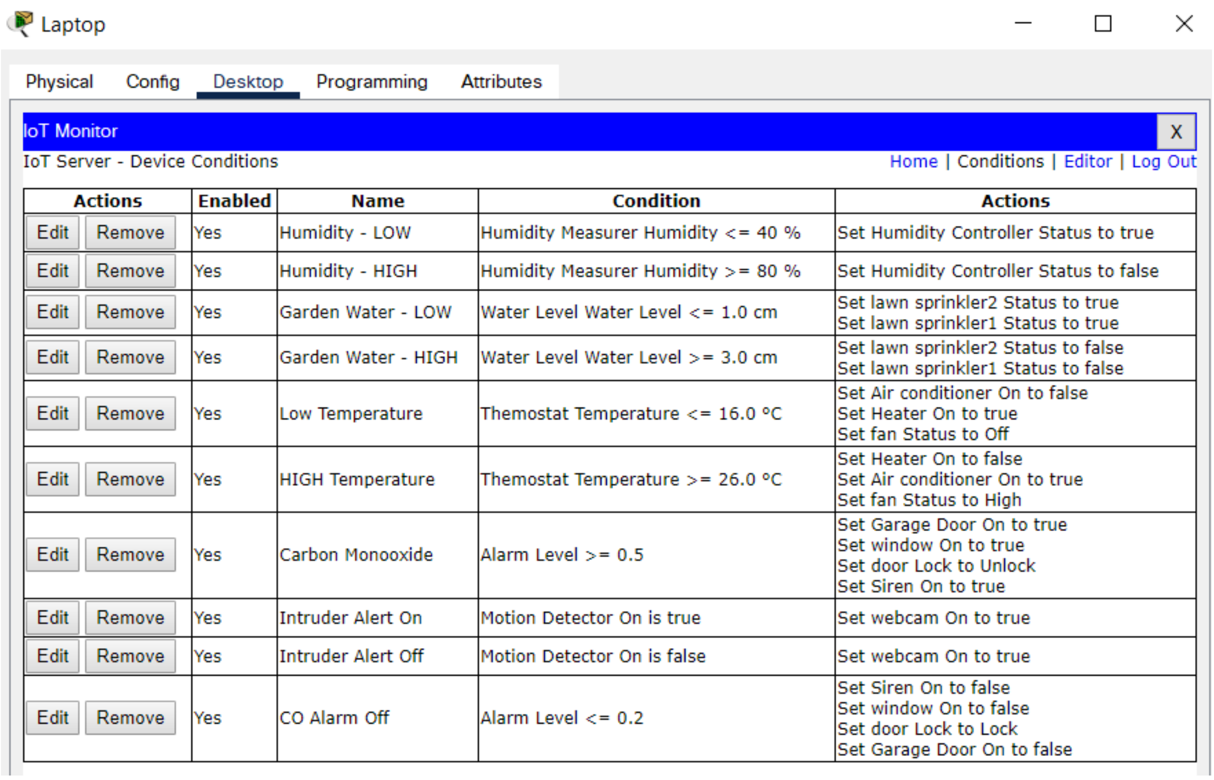
```
    setDeviceProperty(getName(), "state", state)
def updateEnvironment():
    global VOLUME_AT_RATE
    global ENVIRONMENT_IMPACT_DIM
    volumeRatio = float(VOLUME_AT_RATE) / Environment.getVolume()
    print("volume ratios is " + str(volumeRatio))
    print("lalalala " + str(ENVIRONMENT_IMPACT_DIM*2*volumeRatio))
    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()
```

5.9 THE CABLE MODEM is used for connection between home and internet. It provides internet connection. There is no configuration with this particular device in the simulation.

5.10 THE SMARTPHONE is used to remotely access the smart object through a web interface using the URL www.iot.org with an internet connection. It 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.



5.11 THE AUTOMATION SCRIPT ADDED



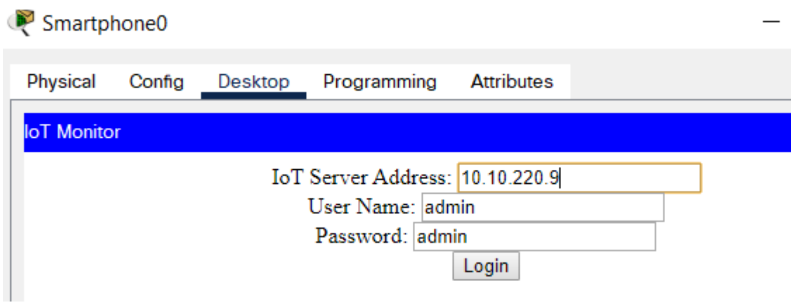
Actions		Enabled	Name	Condition	Actions
Edit	Remove	Yes	Humidity - LOW	Humidity Measurer Humidity <= 40 %	Set Humidity Controller Status to true
Edit	Remove	Yes	Humidity - HIGH	Humidity Measurer Humidity >= 80 %	Set Humidity Controller Status to false
Edit	Remove	Yes	Garden Water - LOW	Water Level Water Level <= 1.0 cm	Set lawn sprinkler2 Status to true Set lawn sprinkler1 Status to true
Edit	Remove	Yes	Garden Water - HIGH	Water Level Water Level >= 3.0 cm	Set lawn sprinkler2 Status to false Set lawn sprinkler1 Status to false
Edit	Remove	Yes	Low Temperature	Themostat Temperature <= 16.0 °C	Set Air conditioner On to false Set Heater On to true Set fan Status to Off
Edit	Remove	Yes	HIGH Temperature	Themostat Temperature >= 26.0 °C	Set Heater On to false Set Air conditioner On to true Set fan Status to High
Edit	Remove	Yes	Carbon Monooxide	Alarm Level >= 0.5	Set Garage Door On to true Set window On to true Set door Lock to Unlock Set Siren On to true
Edit	Remove	Yes	Intruder Alert On	Motion Detector On is true	Set webcam On to true
Edit	Remove	Yes	Intruder Alert Off	Motion Detector On is false	Set webcam On to true
Edit	Remove	Yes	CO Alarm Off	Alarm Level <= 0.2	Set Siren On to false Set window On to false Set door Lock to Lock Set Garage Door On to false

6. EXPERIMENT RESULTS & ANALYSIS

6.1 RESULTS

While all the devices have been configured, they can all be accessed through the smartphone or the laptop with the IoT Monitor Application using the correct username and password. After being connected to the IoT homepage and successfully passing the authentication, the user can then see the list of the connected devices and perform the action he wants.

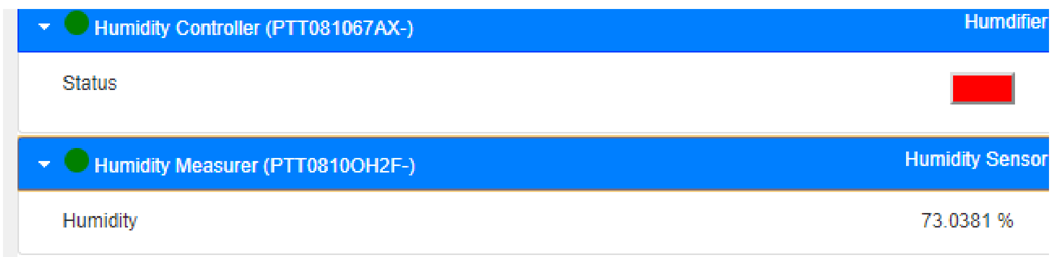
Logging In :



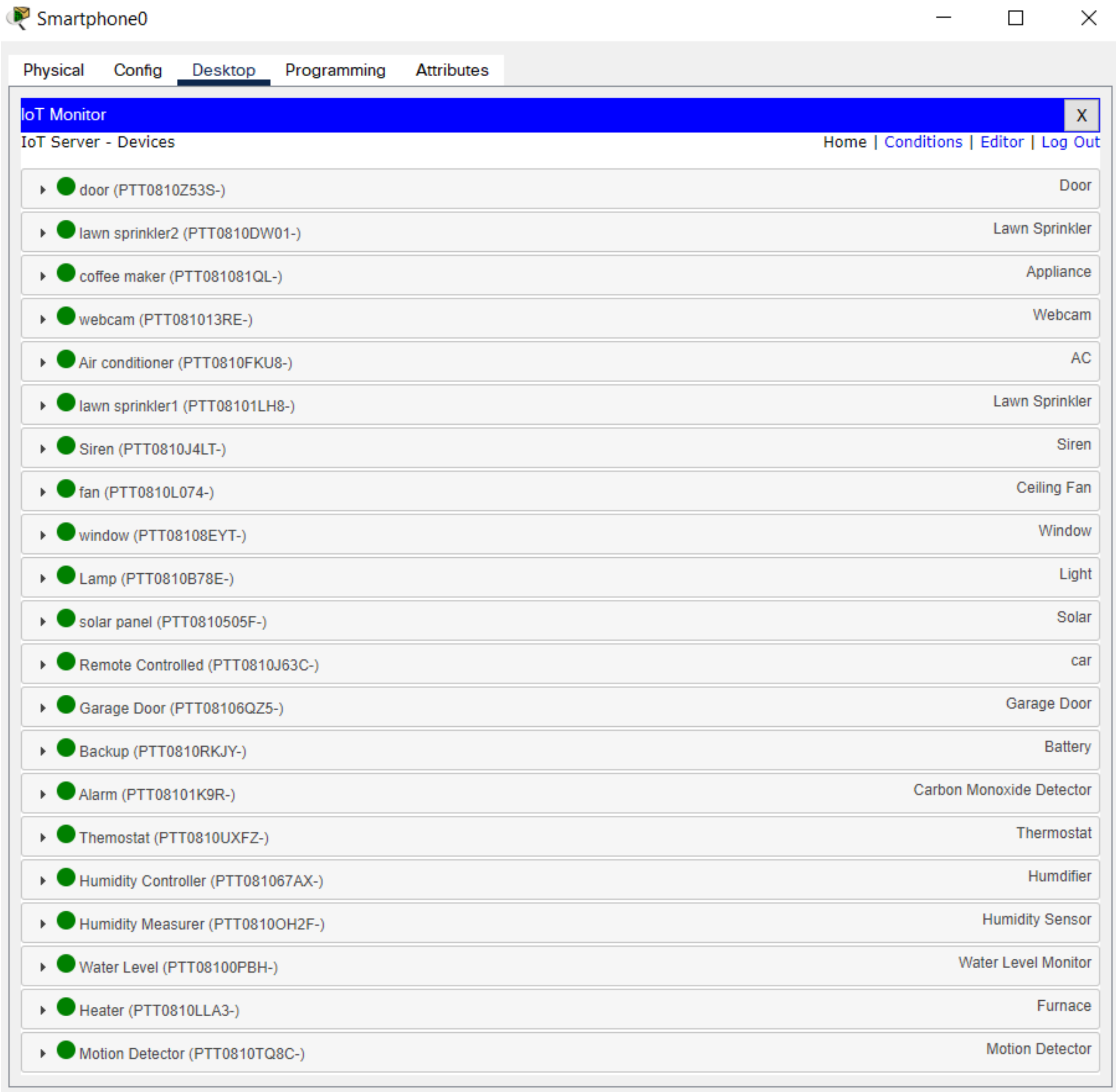
Controlling Devices :

Camera and Coffee Maker Controls-

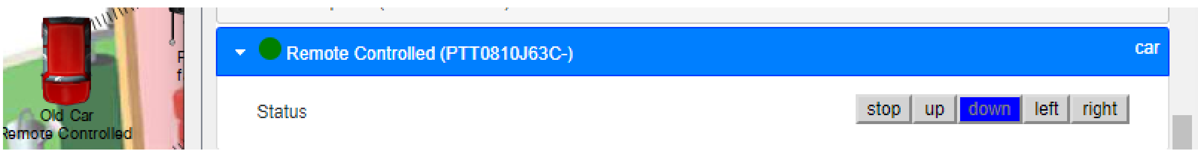
Humidity Controls-



All the devices in the IoT Monitor:



Smart Car:



6.2 RESULT ANALYSIS

The IoT devices can be successfully controlled from the IoT Monitor application. Their status can also be viewed in the application.

The automation is running as programmed with the temperature and the humidity of the house being controlled. The Carbon Monoxide security is also working correctly with the doors, windows opening and the siren starting on high levels. The water sprinklers are also working perfectly.

The Smart Car code also works flawlessly, moving the car up, down, left or right based on the command selected.

6.3 CONCLUSION

This project was to simulate the internet of things using a cisco packet tracer. The idea was to implement and simulate a very common IoT application that is the smart home. Many network devices are used in order to achieve the simulation : gateway, router, cable modem, IoT and DNS servers, Router, switch, cell tower, cloud WAN, central office server 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 a wireless network. The IoT server and the smartphone play a very important role in the simulation because they permit the user to remotely control the IoT devices via the internet. The IoT server is used for smart devices registration while the smartphone is used to remotely access the smart devices registered on the IoT server.

6.4 FUTURE WORK

More IoT devices can be added on to make this a much more complex simulation. The Smart Car can be coded to have more granular control with the axis of rotation being added.

There are many other simulators used to simulate IoT technology like NodeRed or NS3. These powerful software tools can be used to simulate a much more complex simulation with more granular control and better automation controls.

7. REFERENCES

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