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IMPLEMENTATION OF NETWORK DESIGN FOR UNIVERSITIES WITH IOT

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Abstract - The purpose of this project is to set up the network design on a college campus in such a way that network devices will be able to communicate efficiently and help to enhance technology on campus. The servers used in this setup are DHCP, DNS, FTP, IoT, and many more services including web services, mail services and etc. By combining all the technologies such as LAN, WAN, Wireless, and IoT we were successfully able to create a college campus network and a smart office where one authorized personnel can control smart office equipment on the go.

Key Words: Cisco packet tracer, VLAN, VTP, DNS, DHCP, HSRP, FTP, EMAIL SERVICE, and IoT.

1. INTRODUCTION

Computer network design is one in which the interconnection of multiple devices such as a hub, switch, router, bridge, wireless router, wireless bridge, etc. These devices are called network devices. This interconnection of devices helps to communicate between different devices. Figure 1 shows the networking devices.

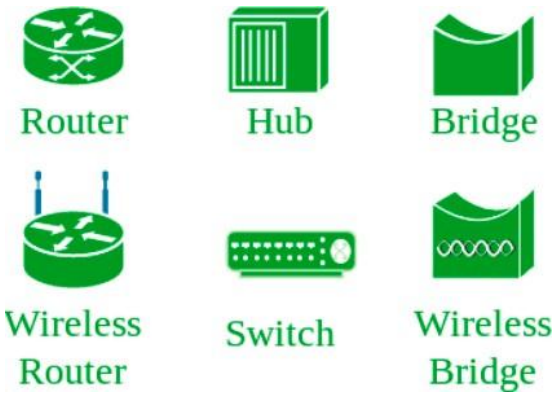

Fig -1: Networking Devices

The arrangement of network devices will be in a different layout. The arrangement of network devices is called network topology. Examples include mesh, ring, star, hybrid, tree, and point-to-point. Aside Figure 2 represents the network topology.

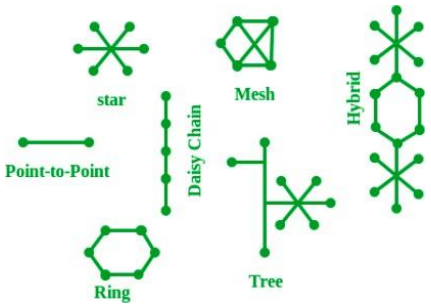

Fig -2: Network Topology

The design of a network in networking follows some set of rules/protocols which is defined by a standard model called the OSI (Open Systems Interconnection) model. It is a reference model that defines the standards for communication protocol. [5] OSI model includes seven-layer such as application layer, presentation layer, session layer, transport layer, network layer, data link layer, and physical layer.

Hence it is also called a seven-layer model. OSI model Developed in 1984, It was initially developed by ISO, the International Organization for Standardization, and is now common practice for learning networking concepts.

OSI model gives the flow of transmission of data from one end device(source) to another end device(destination) in network design [4]. The first three layers from the physical layer are called the hardware layer, the last three layers is called the software layer and the middle transport layer is the heart of the OSI model.

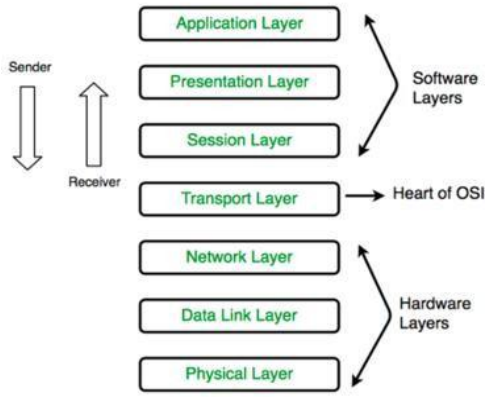

Fig -3: OSI Model

2. RELATED WORK

In a previous study, Yan Haiyan (2001) entitled "Application of VLAN and HSRP technology in the dual-core campus network" aimed to realize the gateway redundancy backup and achieve the aim of load balancing and link backup.

Research conducted by, Isa Shemsi (2017) entitled "Boosting Campus Network Design Using Cisco Packet Trace" where this study was conducted to improve the campus network service, this paper proposed Smart Campus Network Design (SCND) by assimilating internet of thing devices with classical network devices.

Besides, research conducted by Mingyu Lim (2020) entitled "Direct and **Indirect** File Transfer Protocols Between Clients in Client-Server Architecture" proposed a file-transfer protocol (C2CFTP) that efficiently performs file transfer between clients in a client-server architecture.

Research conducted by Marwa Assim (2020) entitled "Design and Implementation of Smart Home using WSN and IoT Technologies" has shown how to design smart home automation

3. PROBLEM FORMULATION

In building a network infrastructure, one of the most important things is how the network can handle link failures and device failures. So to minimize failures in a network, we have a redundancy protocol implemented (HSRP). With HSRP, if one gateway dies, the other gateway will immediately replace the standby gate.

Communication between two or more different local area networks or between wide area networks is the most challenging job, so in this project, we have used the OSPF (Open Shortest Path First) protocol which has the characteristics to choose the shortest path which will evaluate the delay and improves the efficiency of the packet exchange.

Furthermore, we have used technologies such as DHCP to automate the IP address to end devices, FTP to transfer files from one device to another, Email services to communicate, DNS to decode domain names to IP addresses so that browsers can load Internet resources and IoT servers and types of equipment to design the Smart Office. The simulation and implementation have been done using a Cisco packet tracer 8.0.1. [1]

4. CONCEPTUAL MODELLING

At the conceptual model stage, network topology will be made. The network topology will be designed using Cisco packet tracer 8.0.1. Which also acts as a tool for network simulation. The components which are used in the design of the layer 2 and layer 3 VLAN, HSRP, DHCP, DNS, FTP, Web Services and OSPF topologies are:

1. 15 Units of Cisco Switches 2960 series.
2. 32 Units of Computer Devices
3. 6 Units of Cisco Multi-layer switches 3560 series
4. 3 Units of Cisco ISR 4331 routers
5. 6 Units of Servers
6. 1 Unit of IoT Home Gateway
7. 7 Units of IoT types of equipment

5. METHODOLOGY

A. Modelling

This stage will be performed modeling for the simulation. The simulation will be conducted for Inter VLAN communication, HSRP normal condition, HSRP Link Termination, OSPF WAN communication, Email Services, Web Services, FTP service, and IoT-based smart office using Cisco packet tracer.

B. Simulation

At this simulation stage, the authors use the network simulation software Cisco packet tracer 8.0.1., which runs on the Windows 10 operating system. [1]

C. Inter-VLAN Communication

The figure shows the inter-VLAN communication between two end devices from VLAN 2 to VLAN 3 as highlighted in the figure. [2] The Simulation panel describes the path flow and the time taken (in secs) to reach the destination. [5]

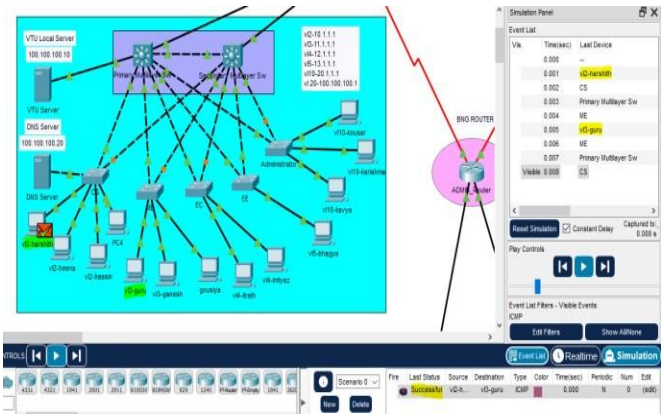

Fig -4: Inter VLAN Communication

D. HOT STANDBY ROUTER PROTOCOL

HSRP is running here for the local subnets created in both the multi-layer switches, currently, Primary switch is in the Active state and the Secondary is in Standby. [5] If Primary fails due to any reason, secondary will overtake as Active. [1] [4]

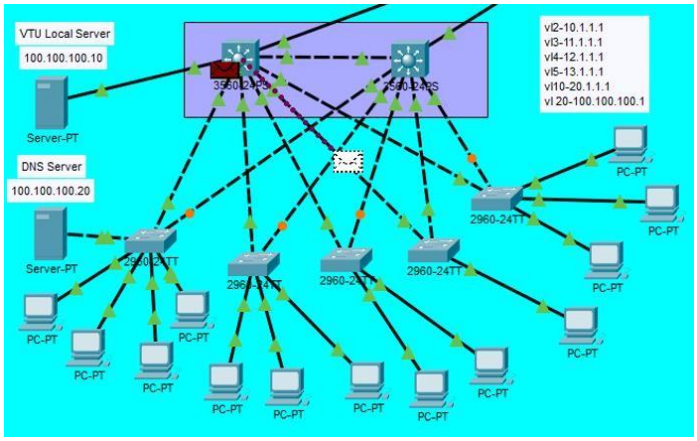

Fig -5: HSRP Path when Primary Switch is Active

```
primary_multilayer_sw$sh standby brief
                     P indicates configured to preempt.
                     |
Interface   Grp  Pri P State    Active          Standby         Virtual IP
V12         2    100   Active   local           10.1.1.2        10.1.1.3
V13         3    100   Active   local           11.1.1.2        11.1.1.3
V14         4    100   Active   local           12.1.1.2        12.1.1.3
V15         5    100   Active   local           13.1.1.2        13.1.1.3
V110        10   100   Active   local           20.1.1.2        20.1.1.3
V120        20   100   Active   local           100.100.100.2   100.100.100.3
```

Fig -6: VLANS in Active Local Primary Switch

Scenario 1:

Let's make Primary Switch's links down and see if the HSRP path takes Secondary switch.

```
primary_multilayer_sw#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
primary_multilayer_sw(config)#int rang
primary_multilayer_sw(config)#int range fa0/1-6
primary_multilayer_sw(config-if-range)#sh
primary_multilayer_sw(config-if-range)#shutdown
```

```
primary_multilayer_sw(config-if-range)#end
primary_multilayer_sw#
primary_multilayer_sw#wr
Building configuration...
[OK]
```

Fig -7: Commands to disable the links of Active Switch

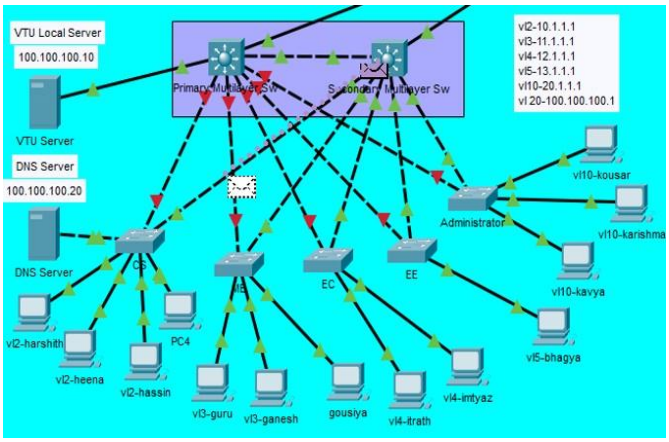

Fig -8: HSRP Path when Primary Switch is Fails

```
secondary_mutilayer_sw$sh standby brief
                     P indicates configured to preempt.
                     |
Interface   Grp  Pri P State    Active          Standby         Virtual IP
V12         2    90    Active   local           unknown         10.1.1.3
V13         3    90    Active   local           unknown         11.1.1.3
V14         4    90    Active   local           unknown         12.1.1.3
V15         5    90    Active   local           unknown         13.1.1.3
V110        10   90    Active   local           unknown         20.1.1.3
V120        20   90    Active   local           unknown         100.100.100.3
```

Fig -9: VLANs in Active Local Secondary Switch

The routers or multilayer switches that are going to participate in HSRP must go through these states before it operates for some role in a network. as shown in figure 10

The initial state is when an Interface is enabled to participate in HSRP. Learn State is when the switch tries to learn the Virtual IP address, and Listen State is when both the routers listen to Hello messages. Speak State is said to be when periodic hello messages will be exchanged and participate in the HSRP election. Standby and Active State are when the router is set to become the next active router and the Active state router forwards the traffic respectively.

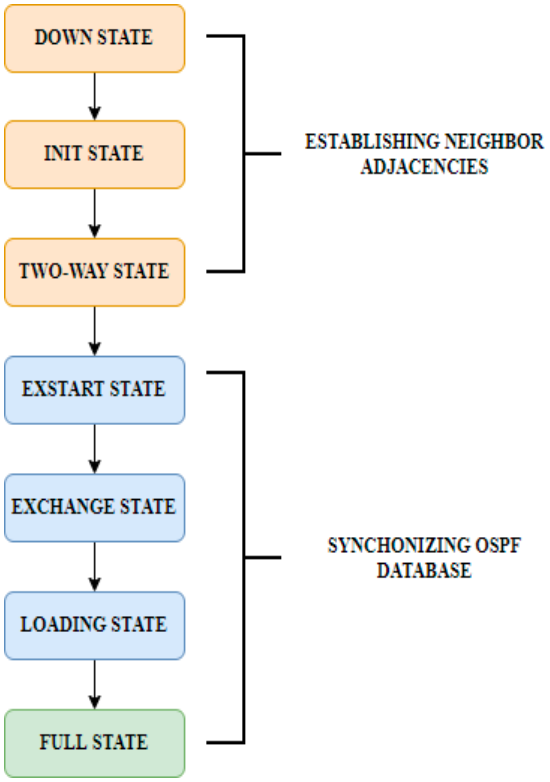

Fig -10: States of HSRP

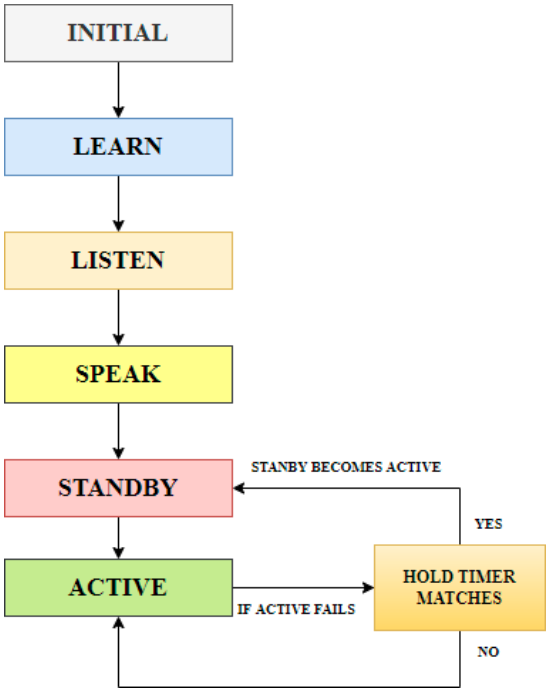

Fig -11: States of OSPF

E. OSPF

OSPF is a routing protocol that is used for Internet Protocol networks. It uses the status of the links to form a network and uses a link-state routing (LSR) algorithm and operates within a single Autonomous System (AS)[9].OSPF is usually used in large and complex networks which gathers the link state information from available routers and develops a network topology. Furthermore, the formed topology is represented as a Routing table to Internet Layer to route the packets by their desired destination.

Before forming the neighborship, the routers have to go through several states where establishing neighbor adjacencies and developing databases would happen. The first three states of OSPF are mainly while Establishing the neighbor adjacencies to form neighborship. The last four states are to Synchronize the OSPF database which contains the link state advertisements as shown in Figure 11.

OSPF detects the variations in network topology, such as failures of links, and forms a new loop-free routing structure within some seconds as the name says, it finds the shortest-path tree for each route that is available in the routing table [9]. It uses Dijkstra's Algorithm. Figure 12 shows the WAN setup and forms the OSPF neighborship among them. [4]

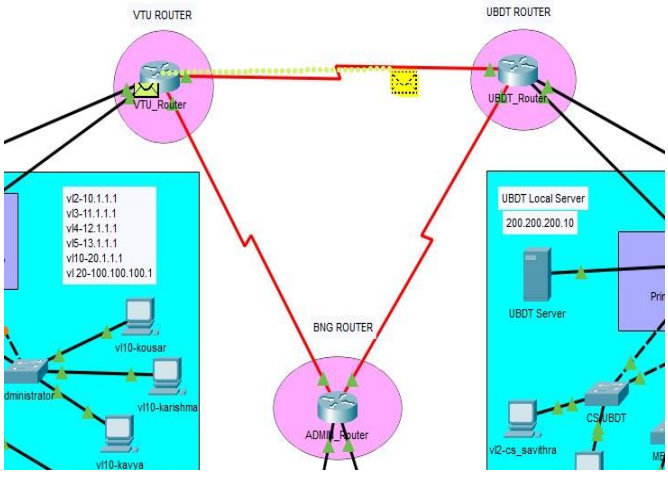

Fig -12: WAN Topology and Communication

```
router ospf 1
 log-adjacency-changes
 network 10.1.1.0 0.0.0.255 area 1
 network 11.1.1.0 0.0.0.255 area 1
 network 12.1.1.0 0.0.0.255 area 1
 network 13.1.1.0 0.0.0.255 area 1
 network 20.1.1.0 0.0.0.255 area 1
 network 200.200.200.0 0.0.0.255 area 1
 network 1.1.1.2 0.0.0.0 area 1
 network 2.2.2.2 0.0.0.0 area 1
 network 3.0.0.0 0.255.255.255 area 1
 network 4.0.0.0 0.255.255.255 area 1
!
```

Fig -13: OSPF Network Advertisements

```
VTU_RTR#sh ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
100.100.100.1     1   FULL/DR         00:00:32    1.1.1.1         GigabitEthernet0/0/0
9.9.9.2           0   FULL/  -        00:00:31    4.4.4.2         Serial0/1/1
7.7.7.2           0   FULL/  -        00:00:31    3.3.3.2         Serial0/1/0
```

Fig -14: OSPF Neighbor Formation

F. EMAIL SERVICES

An email refers to the electronic means of communication by sending and receiving messages over the Internet. Email operates across computer networks, primarily the Internet, and also local area networks.

Similarly, we have created a group of users and passwords respectively for each of the computers in our network topology so that they can communicate via email.

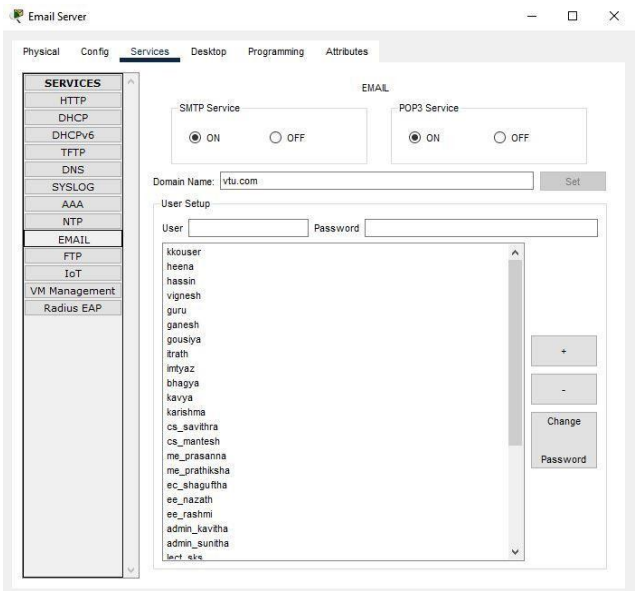

Fig -15: Enabling Email Services and Creating User and passwords in a Server

In Figure 16, the Incoming and Outgoing Mail Server is **vtu.com**,which will be translated to the actual IP with the help of DNS server.

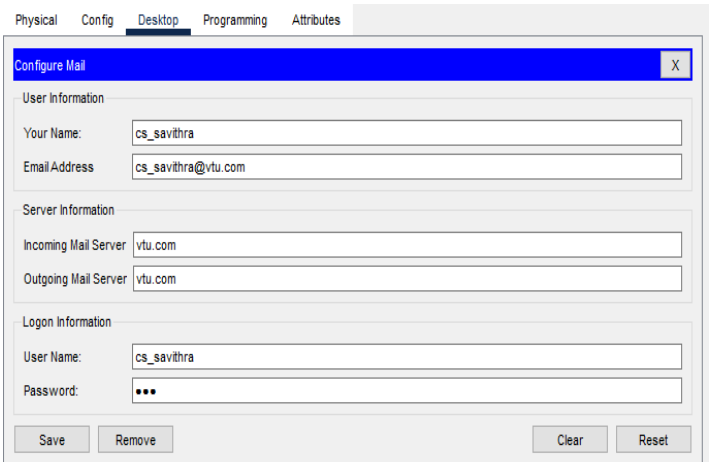

Fig -16: Configuring Email in a Computer device

Email Composition:

In Figure 17, as highlighted, when an email is composed to some other user, it will reach to DNS server as we have specified vtu.com as our Incoming and outgoing server as shown in Figure 16.

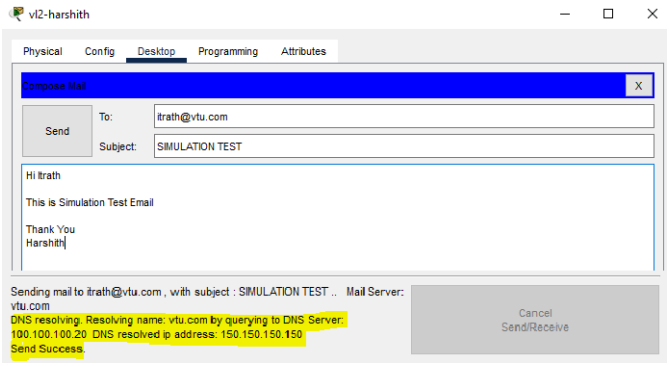

Fig -17: Configuring Email in a Computer device

Figure 18 shows that the composed email has been received by the receiver

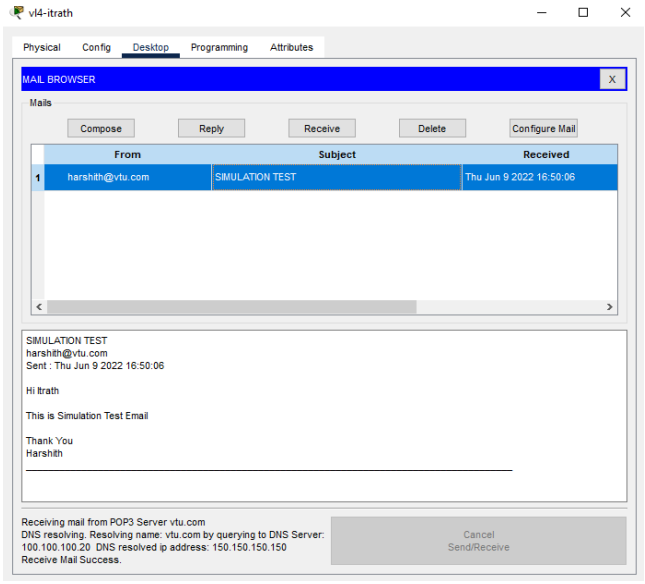

Fig -18: GUI view of Email Browser

G. WEB SERVICES

A service offered by an electronic device to another electronic device, communicating with each other via the Internet, or a server running on a computer device, listening for requests at a particular port over a network, serving web documents (HTML, JSON, XML, images).

Figure 19 shows the VTU homepage and from there, with the help of Hyperlinks, we can navigate to other pages as well.

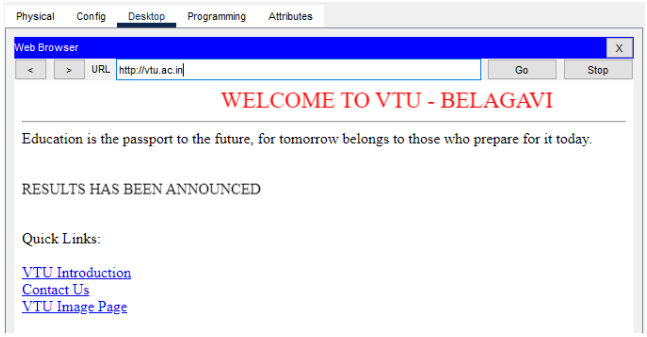

Fig -19: HTML page of VTU.AC.IN

H. IOT – SMART OFFICE

Including various smart objects which are used for implementing office automation such as chic windows, chic fans, chic lights, chic doors, webcams and various sensors. [1] The Home Gateway is used for controlling the objects and sensors, which are providing a programming environment for controlling objects that are connected and provides control mechanisms through the registration of Home Gateway smart devices. [3]

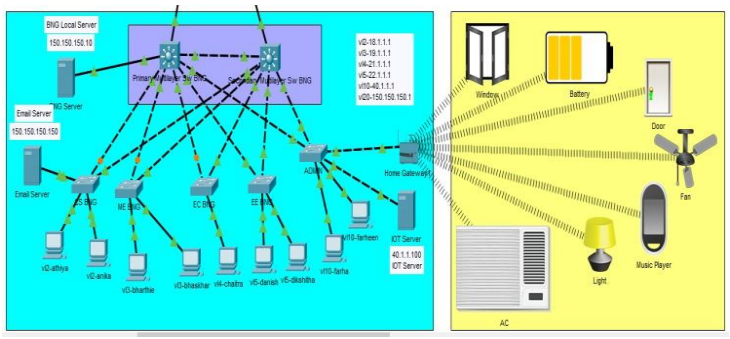

Fig -20: Network Topology of IOT based smart office

Fig -21: Home Gateway Internet and Ethernet Port

Again with DNS resolutions for HTTP page "iot_server", the browser redirects to the Login page of the IoT server, where we can control all the smart IoT devices from any computer in our network topology.

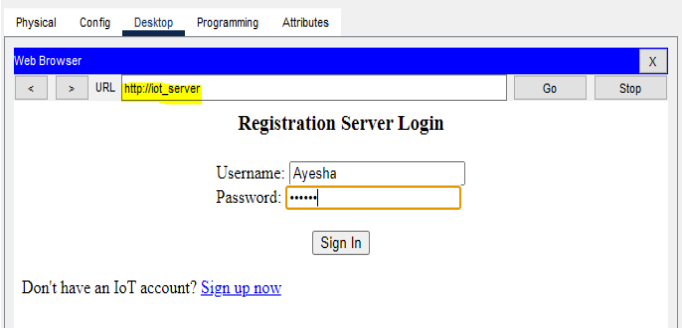

Fig -22: HTML page of iot_server

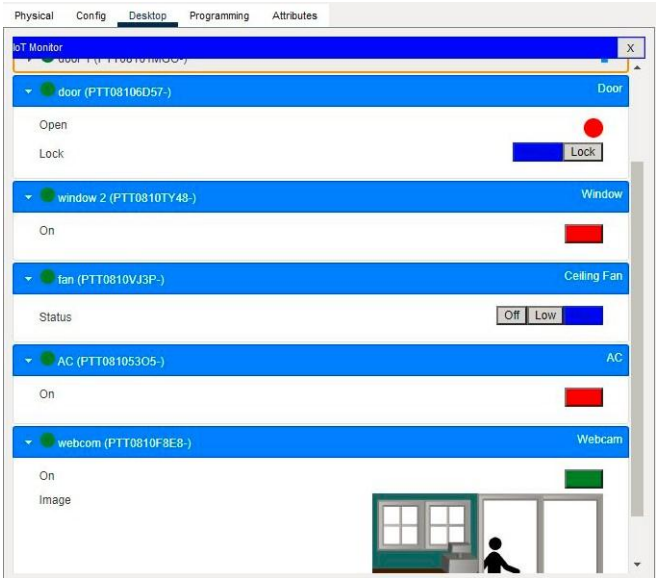

Fig -23: Registered IOE devices with their status

After registering the smart device to the home gateway, [8] the figure above shows that all devices are accessed by legitimate users via the web and this can be done from any of the end devices in any site as per our topology.

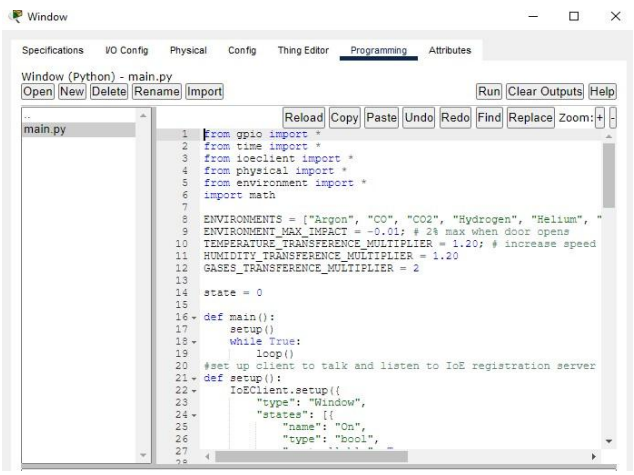

Fig -24: IoT Programming Environment

6. CONCLUSION

In this article, we used the Cisco packet tracer version 8.0.1. to introduce various protocols such as DNS, DHCP, HSRP, OSPF, FTP, and IoT-based smart office set up in a single platform, where anyone can communicate with anybody. The main motto of this article is to have network redundancy and transparency for everyone. Hence we can conclude that we have designed and simulated college campus network design with the smart office.

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