

# **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 sevenlayer 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

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# **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

		P	indicat	es 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/2.
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





secondary_	mutila	yer_sw	\$sh stan	dby brief		
		- 1	indicat	es configure	d 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.



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INITIAL DOWN STATE LEARN ESTABLISHING NEIGHBOR INIT STATE ADJACENCIES LISTEN TWO-WAY STATE SPEAK EXSTART STATE STANBY BECOMES ACTIVE STANDBY EXCHANGE STATE YES SYNCHONIZING OSPF HOLD TIMER DATABASE ACTIVE MATCHES IF ACTIVE FAILS LOADING STATE NO Fig -11: States of OSPF FULL STATE

Fig -10: States of HSRP

#### 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



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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
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.

ysical Config S	ervices Desktop Programming Attribute	.5	
SERVICES		EMAIL	
HTTP	SHTD Service	POP2 Service	
DHCP	SMTP Service	POPS Service	
DHCPv6	O OFF	ON     OFF	
TFTP		0	
DNS	and another Provide the State of State		
SYSLOG	Domain Name: vtu.com		Set
AAA	User Setup		
NTP			
EMAIL	Password	l	
FTP	kkouser	^	
IoT	heena		
/M Management	hassin		
Radius FAP	vignesn		
riddidd Er i	ganesh		
	gousiya		-
	itrath		+
	imtyaz		
	bhagya		-
	kavya		
	cs savibra		Change
	cs mantesh		
	me_prasanna		Password
	me_prathiksha		140011014
	ec_shaguftha		
	ee_nazath		
	ee_rashmi		
	admin_kavitha		

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.

Physical	Config	Desktop	Programming	Attributes		 	
Configure I	Mail						Х
User Info	rmation						
Your Nar	ne:	cs_savithra	1				
Email Address cs_savithra@vtu.com							
Server In	formation						
Incoming	Mail Server	vtu.com					
Outgoing	Mail Server	vtu.com					
Logon Inf	ormation						
User Nar	ne:	cs_savithra	1				
Passwor	d:	•••					
Save	Re	move				Clear	Reset

#### 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.

🔻 vl2-harshith	1							-		×
Physical C	Config De	sktop	Programming	Attributes						
Compose Mail										х
Grad	To:	itrath@	gvtu.com							
Send	Send Subject: SIMULATION TEST									
Hi Itrath										
This is Simula	tion Test Emai	l .								
Thank You Harshith										
Sending mail to i vtu.com	itrath@vtu.co	m , with	n subject : SIMUL.	ATION TEST	Mail Server:					
DNS resolving. F 100.100.100.20 Send Success.	Resolving nar DNS resolve	ne: vtu. ed ip ade	com by querying dress: 150.150.1	to DNS Serve 50.150	r.		Ca Send/	Receive		



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



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vl4-itrat	th				-		×
Physical	Config Deskto	op Programming	Attributes				
	NARED						×
Mails	WSER .						^
mano	Company	Dank	Dessive	Delete	CanEnural	1-11	
	Compose	керіу	Receive	Delete	Configure w		
	From		Subject		Receive	d	
1	harshith@vtu.com	SIMULATIC	ON TEST	Thu J	un 9 2022 16:50:	06	
<							>
SIMULAT	ION TEST						
harshith( Sent : Th	@vtu.com iu Jun 9 2022 16:50:06	6					
Hitrath							
This is Si	imulation Test Email						- 1
Thank Yo	ou						- 1
Harshith							- 1
							- 1
Dessiving	mail from DOD2 Social	ar utu oom					
DNS resol	lving. Resolving name:	: vtu.com by querying f	o DNS Server:	Cance	el		
100.100.1	00.20 DNS resolved i	ip address: 150.150.15	0.150	Send/Rec	eive		
Receive N	ial Success.						

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.

Physical	Config	Desktop	Programming	Attributes						
Web Brows	ser									х
<	> URL	http://vtu.ac.	in					Go	s	top
			WE	LCOM	ETO	VTU ·	- BEL	AGAVI		
Educat	ion is the	e passport	to the future,	for tomorr	ow belon	gs to tho	se who p	repare for it	today.	
RESUI	TS HAS	S BEEN A	NNOUNCEI	)						
Quick I	Links:									
<u>VTU In</u> <u>Contac</u> <u>VTU I</u> n	ntroducti t Us nage Paj	ion ge								

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

ODULES 0		Physical Device View		
	Zoom in	Original Size	Zoom Out	
(1:2)				
	Antonio II Antonio II Antonio II Antonio Antonio II Antonio Antonio II			

### 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.

Physical Config Desktop Programming Attributes		
Web Browser		Х
< > URL http://iof_server	Go	Stop
Registration Server Login		
Username: Ayesha		
Password:		
Sign In		
Don't have an IoT account? <u>Sign up now</u>		

**Fig -22:** HTML page of iot\_server



hysical	Config	Desktop	Programming	Attributes	
T Monitor	0011(1110		-,		
👻 🌑 d	oor (PTT08	106D57-)			Door
Oper	1				•
Lock					Lock
• 🖲 w	rindow 2 (P	FT0810TY	48-)		Window
On					
<b>- O</b> fi	an (PTT081	0VJ3P-)			Ceiling Fan
Statu	IS				Off Low
• 🔍 A	C (PTT081	05305-)			AC
On					-
• • w	vebcom (PT	T0810F8E	8-)		Webcam
On					
Imag	e				

**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.

specifications	VO Config	Physical Config Thing Editor Programming Attributes	
Vindow (Pytho Open New De	n) - main.p lete Rena	me) Import Run Clear Outputs F	lel
	*	Reload Conv Pasta Lindo Redo Find Replace Zoom:	F
nain.py		1 From min import a	U
		2 from time import *	
		3 from ideclient import *	- 1
		4 from physical import *	
		5 from environment import *	
		6 import math	
		7	. 4
		8 ENVIRONMENTS = ["Argon", "CO", "CO2", "Hydrogen", "Helium",	
		9 ENVIRONMENT_MAX_IMPACT = -0.01; # 2% max when door opens	
		10 TEMPERATURE_TRANSFERENCE_MULTIPLIER = 1.20; # increase speed	1
		11 HUMIDITY_TRANSFERENCE_MULTIPLIER = 1.20	
		12 GASES_TRANSFERENCE_MULTIPLIER = 2	
		13	
		14 state = 0	
		10 + German():	
		19 - While True	
		19 loop()	
		20 #set up client to talk and listen to ToE registration server	2
		21 + def setup():	
		22 - IoEClient.setup({	
		23 "type": "Window",	
		24 - "states": [{	
		25 "name": "On",	
		26 "type": "bool",	

**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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