Computer Science 3-1

INTER-VLAN COMMUNICATION IN A CAMPUS NETWORK

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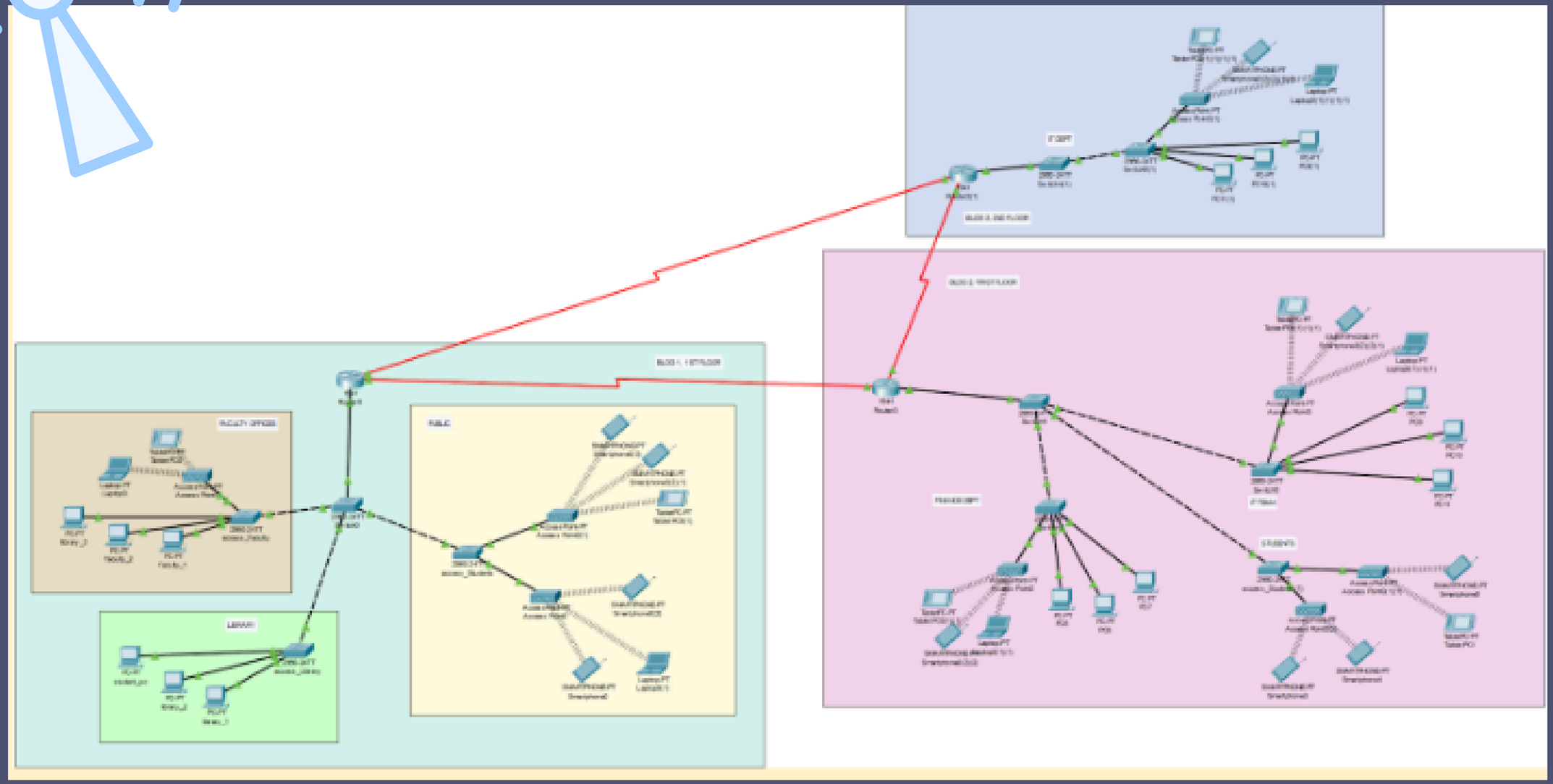
NETWORKS AND COMMUNICATIONS - FINAL PROJECT - CASE STUDY

A typical campus network has a coverage range spanning across adjacent buildings and multiple floors of one building. The main objective of the case study is to logically segment a campus network while retaining communications between devices in the same VLAN even if they connect from different access points. Doing so provides devices with a connection to their respective VLANs regardless of which subnet they use.

ABSTRACT

NETWORK DESIGN



DESCRIPTION OF DEVICES

Namely, there are five types of devices used in the network design: **routers, core and access switches, access points, PCs, and wifi-enabled devices such as laptops, smartphones, and tablets.**

The **routers** have the same number of subinterfaces as the VLANs their respective core switches relay to them. Additionally, they are equipped with High-speed WAN Interface Cards (HWIC) which allows communication between routers.
The **core switches** contain all the VLANs used in the campus building they are physically located at. Straight-through copper cables are used to connect the Gigabit Ethernet ports of both the core switches and the routers.

On the other hand, the **access switches** only have the VLANs that they need to provide network connectivity to their respective end-users. Crossover copper cables are used to connect the Gigabit Ethernet ports of the access switches to the Fast Ethernet ports of core switches.

DESCRIPTION OF DEVICES

The **access points** are made simple just for the purpose of the simulation, using only WPA2-PSK authentication and AES encryption. However, for public wifi for students, they will not use any encryption and authentication protocols and simply be assigned with non-default SSIDs. They are connected to the Fast Ethernet ports of the access switches using straight-through copper cables.

The **PCs and wireless devices** are given their IP addresses using Dynamic Host Configuration Protocol (DHCP) when they connect to their respective VLANs. Much like the access points, the PCs are connected to the Fast Ethernet ports of the access switches using straight-through copper cables, while the wireless devices use 2.4 GHz band and specific WPA2-PSK pass phrases to connect to the access points.

Additionally, the network design follows a **hierarchical star logical topology** as the core switch serves as a central point for communications between VLANs, and the access switches inherit at most two VLANs from the core switch for specific end-user devices to connect to.

DESCRIPTION OF DEVICES

Lastly, the IP addressing scheme for the VLANs and their connected devices are as follows:

VLAN 11: Faculty
- **Router subinterface:** 192.168.11.1
- **DNS server:** 192.168.11.1
- **End-user Devices:** starting from 192.168.11.2 / 24

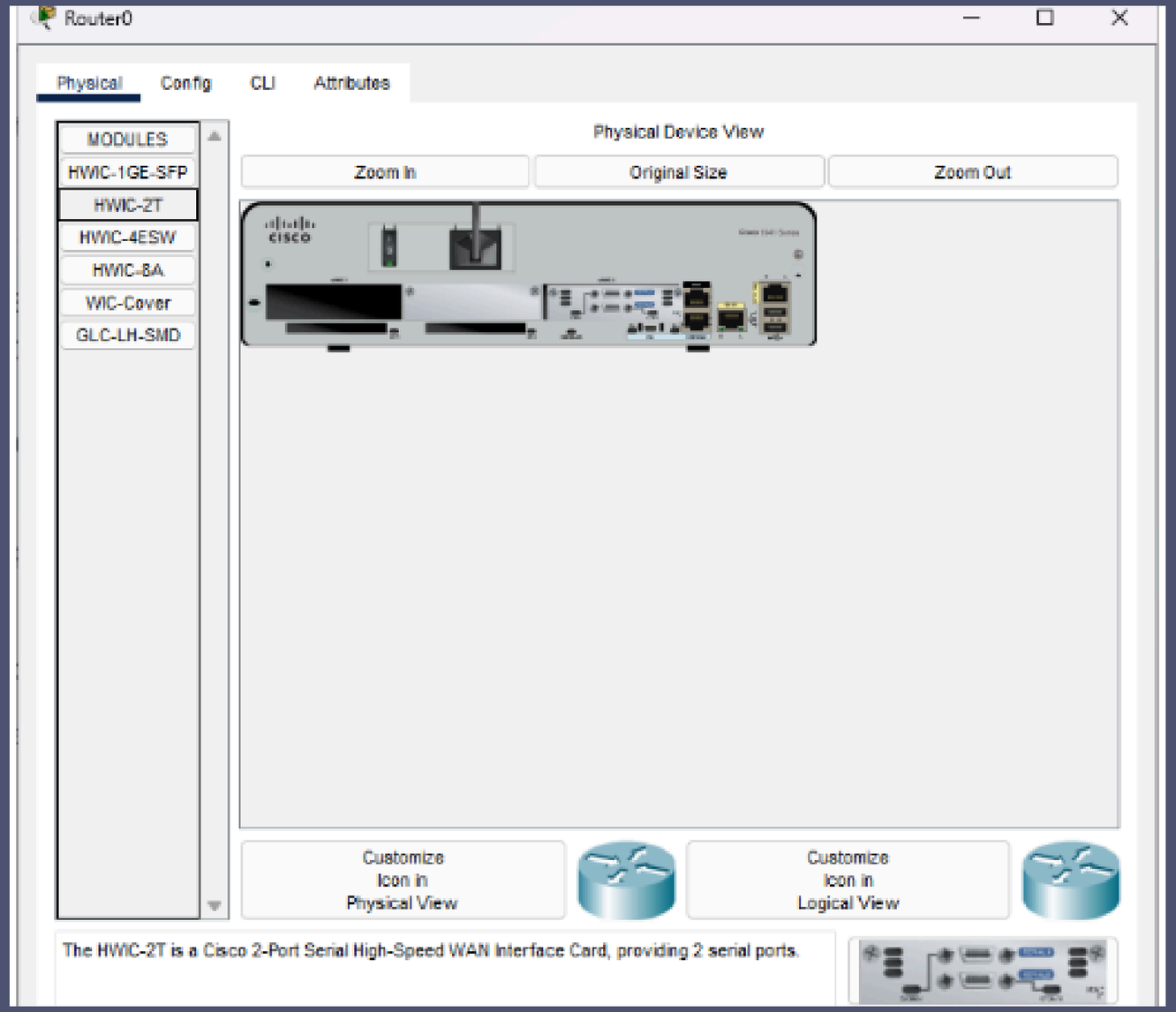
VLAN 12: Library
- **Router subinterface:** 192.168.12.1
- **DNS server:** 192.168.12.1
- **End-user Devices:** starting from 192.168.12.2 / 24

VLAN 13: Students
- **Router subinterface:** 192.168.13.1
- **DNS server:** 192.168.13.1
- **End-user Devices:** starting from 192.168.13.2 / 24

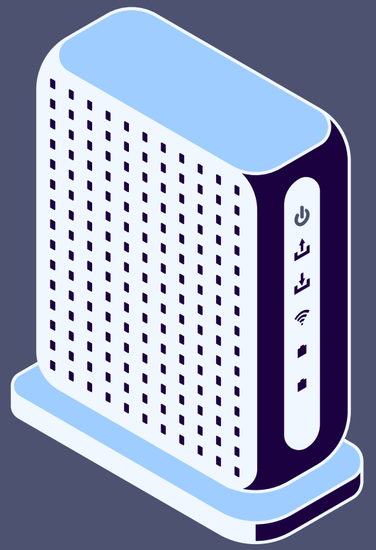
VLAN 14: IT_Dept
- **Router subinterface:** 192.168.14.1
- **DNS server:** 192.168.14.1
- **End-user Devices:** starting from 192.168.14.2 / 24

VLAN 15: Finance
- **Router subinterface:** 192.168.15.1
- **DNS server:** 192.168.15.1
- **End-user Devices:** starting from 192.168.15.2 / 24

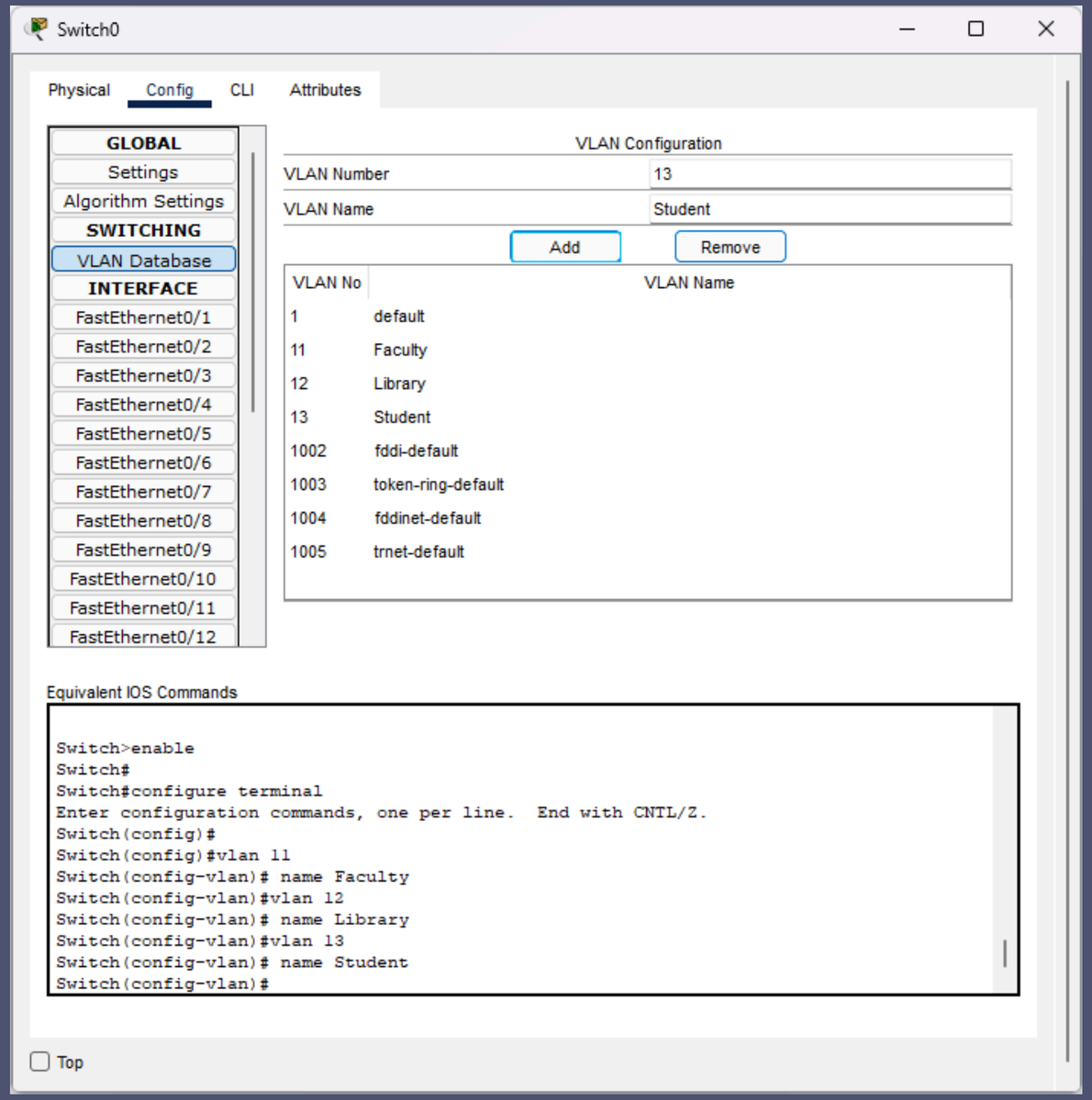
IMPLEMENTATION



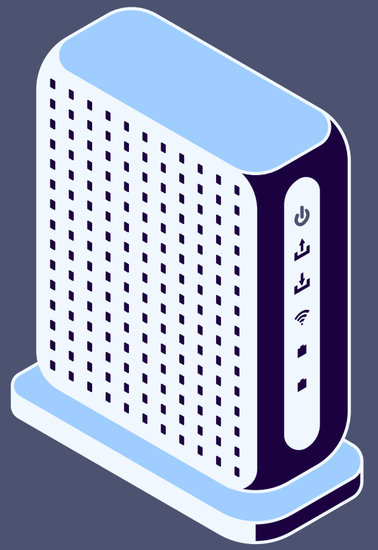
1. **Create a router and install the HWIC-2T module.**



IMPLEMENTATION



2. Create a switch and add the VLANs it will manage and send to the router through its gigabit ethernet port.



IMPLEMENTATION

Switch0

Physical | Config | CLI | Attributes

FastEthernet0/9
FastEthernet0/10
FastEthernet0/11
FastEthernet0/12
FastEthernet0/13
FastEthernet0/14
FastEthernet0/15
FastEthernet0/16
FastEthernet0/17
FastEthernet0/18
FastEthernet0/19
FastEthernet0/20
FastEthernet0/21
FastEthernet0/22
FastEthernet0/23
FastEthernet0/24
GigabitEthernet0/1
GigabitEthernet0/2

GigabitEthernet0/1

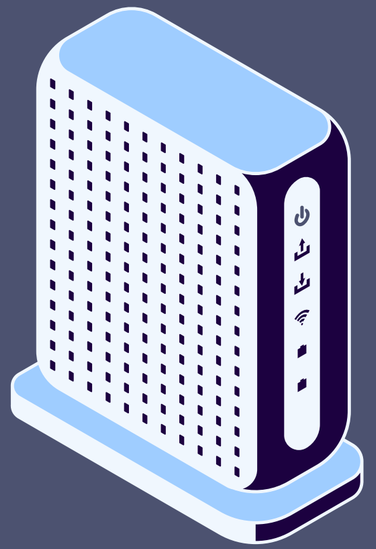
Port Status: On
Bandwidth: 1000 Mbps / 100 Mbps / 10 Mbps / Auto
Duplex: Half Duplex / Full Duplex / Auto

Trunk
VLAN: 11-13
Tx Ring Limit: 10

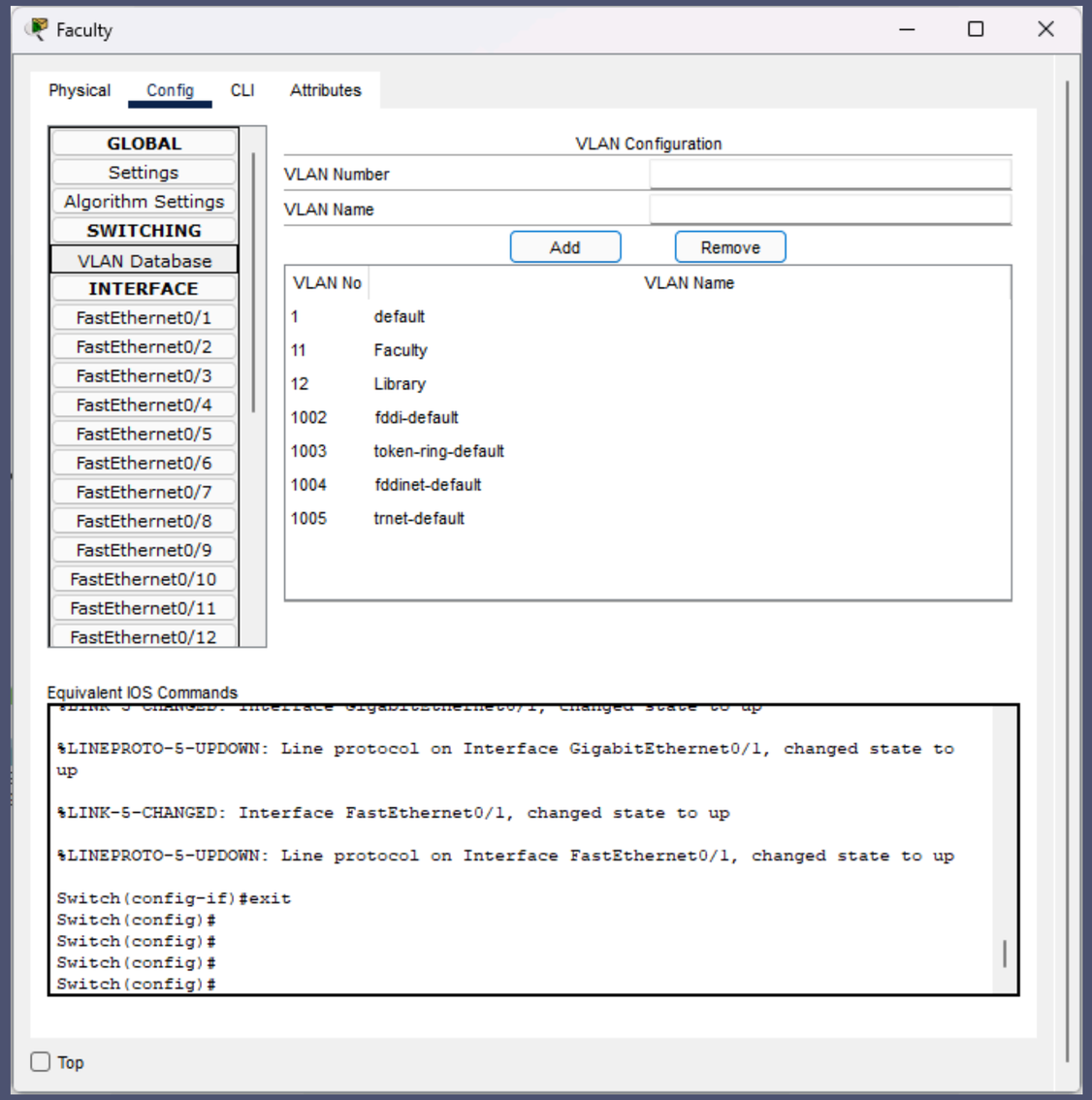
Equivalent IOS Commands

```
Switch(config-if)#exit
Switch(config)#interface GigabitEthernet0/1
Switch(config-if)#
Switch(config-if)#
Switch(config-if)#switchport trunk allowed vlan remove 1
Switch(config-if)#
Switch(config-if)#exit
Switch(config)#interface GigabitEthernet0/1
Switch(config-if)#switchport trunk allowed vlan 11-13
Switch(config-if)#
Switch(config-if)#exit
Switch(config)#interface GigabitEthernet0/1
Switch(config-if)#
```

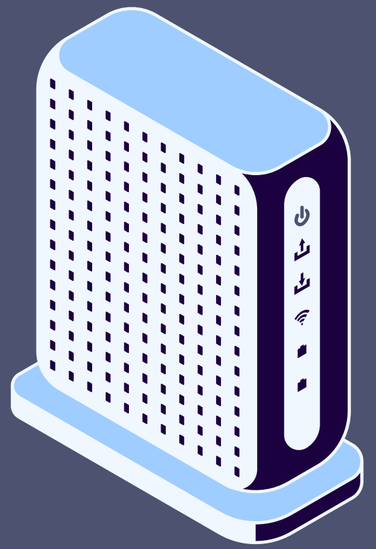
Top



IMPLEMENTATION



3.Create as many access switches as there are VLANs, but each containing only one or two VLANs in their own VLAN database. This allows communication between some VLANs while the rest are isolated.



IMPLEMENTATION

Library

Physical | Config | CLI | Attributes

GLOBAL
- Settings
- Algorithm Settings

SWITCHING
- VLAN Database

INTERFACE
- FastEthernet0/1
- FastEthernet0/2
- FastEthernet0/3
- FastEthernet0/4
- FastEthernet0/5
- FastEthernet0/6
- FastEthernet0/7
- FastEthernet0/8
- FastEthernet0/9
- FastEthernet0/10
- FastEthernet0/11
- FastEthernet0/12

VLAN Configuration

VLAN Number

VLAN Name

Add | Remove

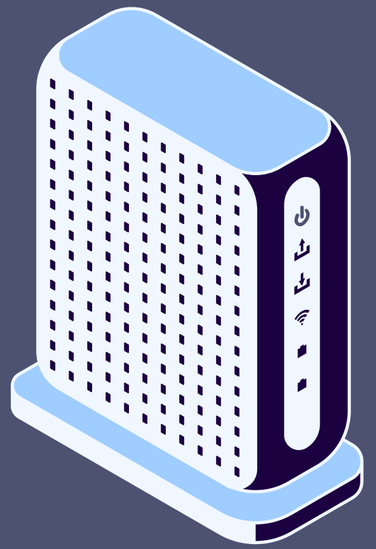
VLAN No	VLAN Name
1	default
12	Library
13	Students
1002	fddi-default
1003	token-ring-default
1004	fddinet-default
1005	trnet-default

Equivalent IOS Commands

```
Switch(config)#
Switch(config)#vlan 13
Switch(config-vlan)# name Students
Switch(config-vlan)#
Switch(config-vlan)#end
Switch#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Switch(config)#
Switch(config)#
%SYS-5-CONFIG_I: Configured from console by console

Switch(config)#
Switch(config)#
```

Top



IMPLEMENTATION

Students

Physical | Config | CLI | Attributes

GLOBAL
- Settings
- Algorithm Settings

SWITCHING
- VLAN Database

INTERFACE
- FastEthernet0/1
- FastEthernet0/2
- FastEthernet0/3
- FastEthernet0/4
- FastEthernet0/5
- FastEthernet0/6
- FastEthernet0/7
- FastEthernet0/8
- FastEthernet0/9
- FastEthernet0/10
- FastEthernet0/11
- FastEthernet0/12

VLAN Configuration

VLAN Number

VLAN Name

Add | Remove

VLAN No	VLAN Name
1	default
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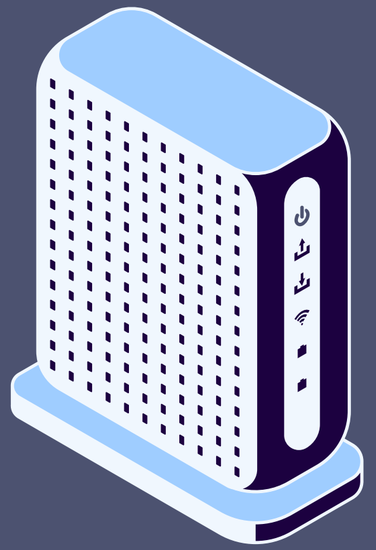
Equivalent IOS Commands

```
Switch(config-if)#exit
Switch(config)#
Switch(config)#vlan 13
Switch(config-vlan)# name Students
Switch(config-vlan)#
Switch(config-vlan)#end
Switch#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Switch(config)#
Switch(config)#
%SYS-5-CONFIG_I: Configured from console by console
```

Top



IMPLEMENTATION

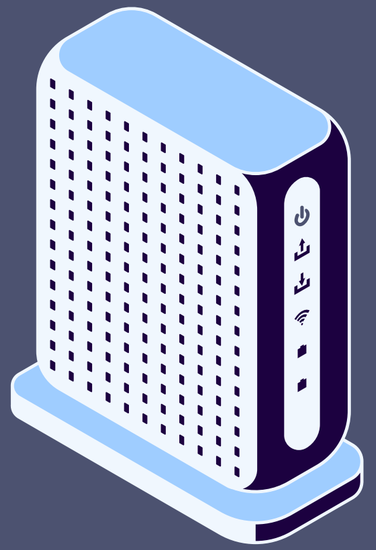
Router0

Physical Config CLI Attributes

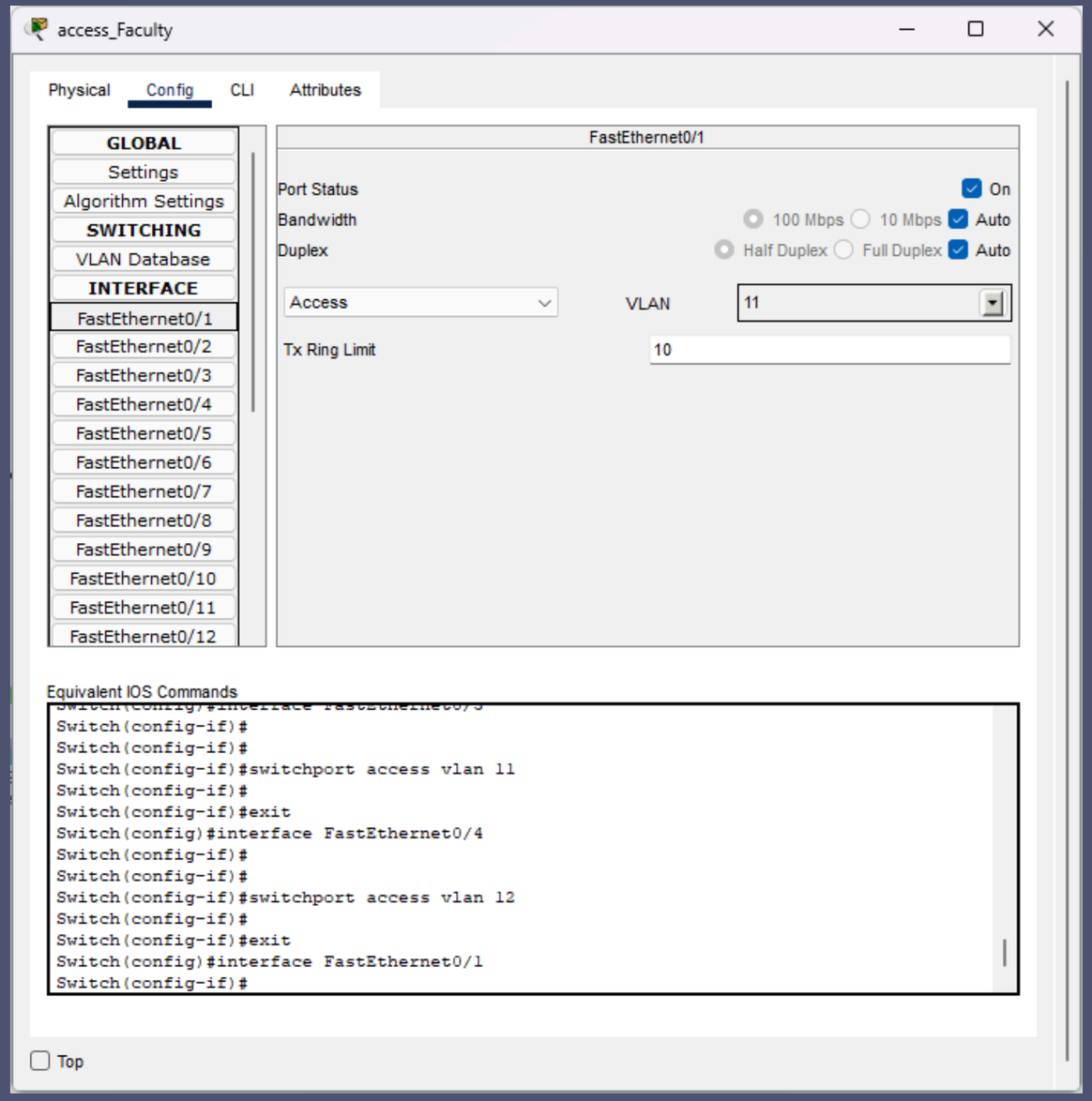
IOS Command Line Interface

```
%LINK-5-CHANGED: Interface GigabitEthernet0/0.11, changed state to up

%LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet0/0.11, changed state to
up

Router(config-subif)#encap
Router(config-subif)#encapsulation dot1q 11
Router(config-subif)#ip address 192.168.11.1 255.255.255.0
Router(config-subif)#ex
Router(config)#service dhcp
Router(config)#ip dhcp pool Faculty
Router(dhcp-config)#network 192.168.11.0 255.255.255.0
Router(dhcp-config)#dns
Router(dhcp-config)#dns-server 192.168.11.1
Router(dhcp-config)#ex
Router(config)#do wr
Building configuration...
[OK]
Router(config)#int gig0/0.12
Router(config-subif)#
%LINK-5-CHANGED: Interface GigabitEthernet0/0.12, changed state to up

%LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet0/0.13, changed state to
up

Router(config-subif)#encapsulation dot1q 12
Router(config-subif)#ip address 192.168.12.1 255.255.255.0
Router(config-subif)#ex
Router(config)#service dhcp
Router(config)#ip dhcp pool Library
Router(dhcp-config)#network 192.168.12.0 255.255.255.0
Router(dhcp-config)#dns-server 192.168.12.1
Router(dhcp-config)#ex
Router(config)#do wr
Building configuration...
[OK]
Router(config)#
```

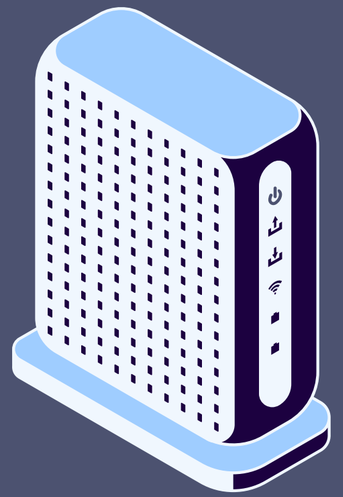
4. **Add all existing VLANs to the router after which perform encapsulation and arrange their DHCP and DNS configurations.**



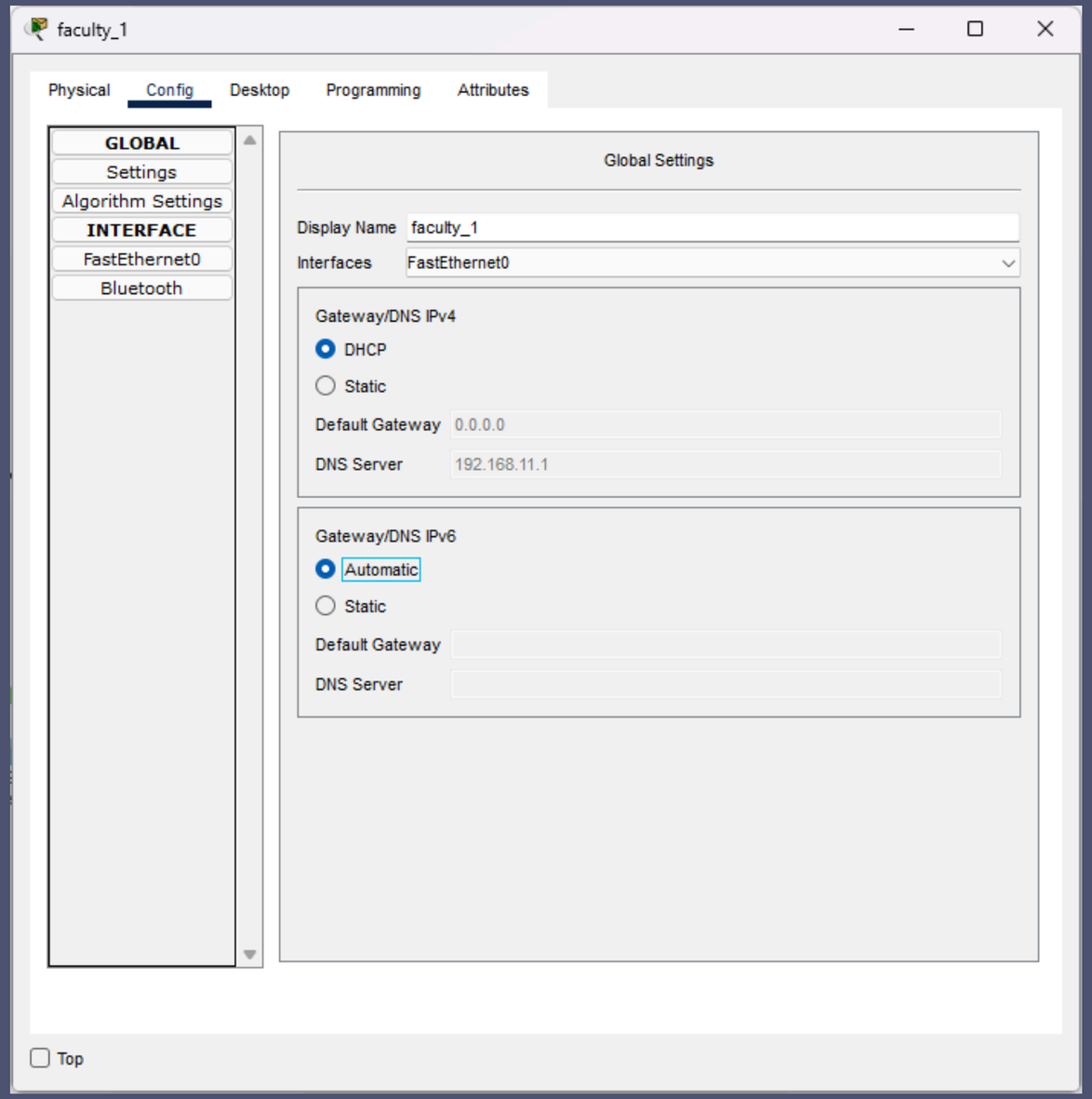
IMPLEMENTATION



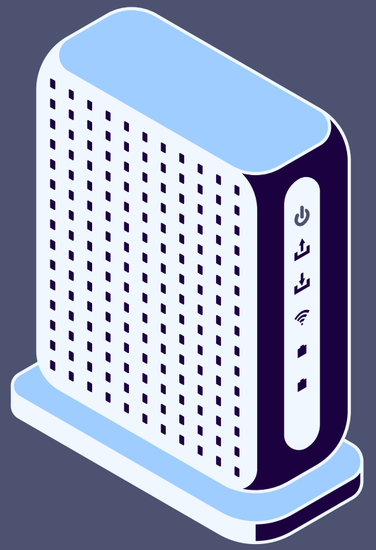
5.**Configure the Fast Ethernet ports of the access switches to provide connectivity to specific VLANs.**



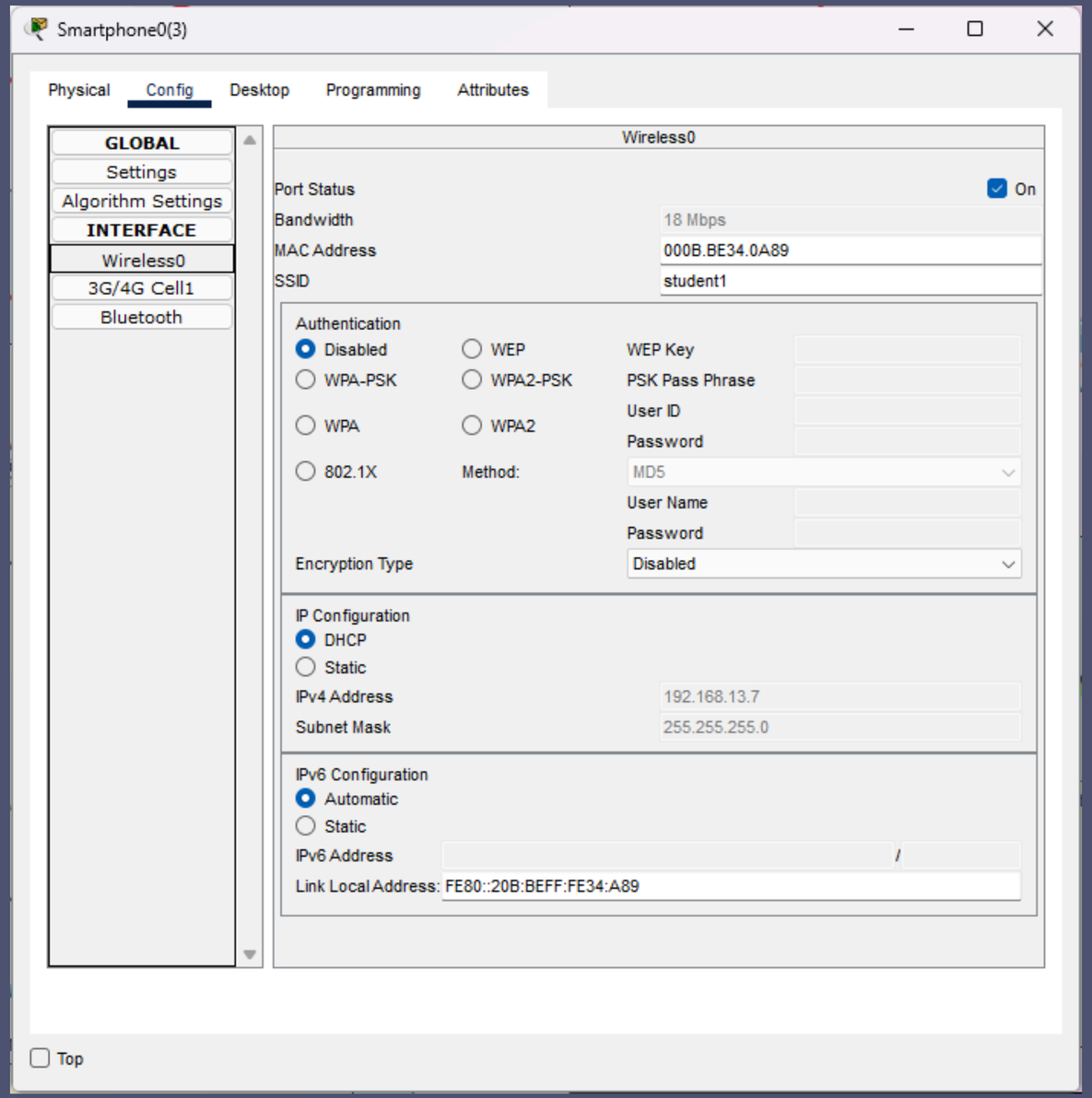
IMPLEMENTATION

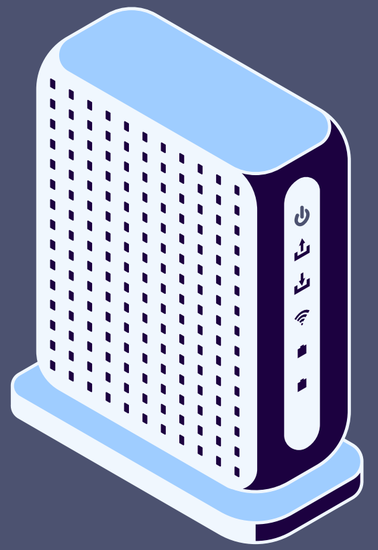


6. After connecting devices to the access switches, configure their network settings to enable DHCP, allowing devices to receive their IP addresses from the router and connect to a DNS server.



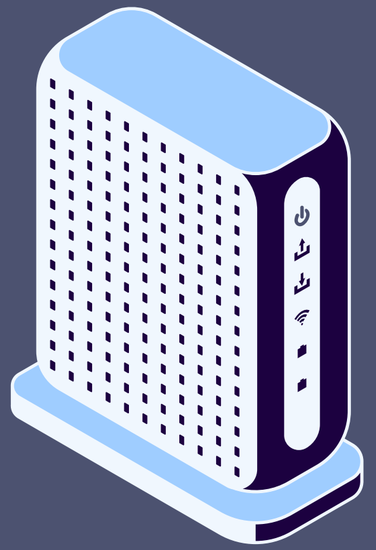
IMPLEMENTATION



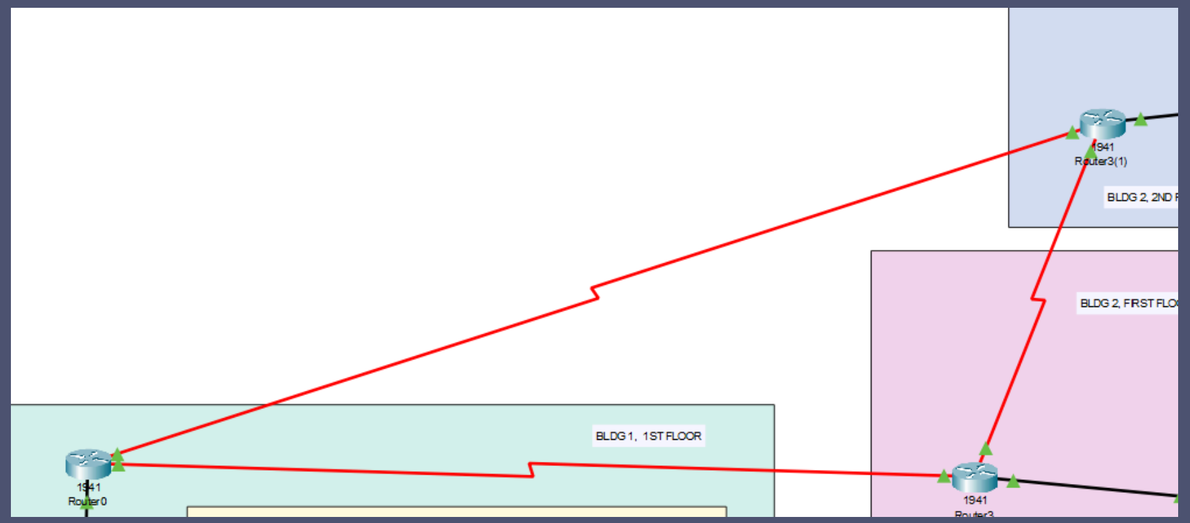


IMPLEMENTATION

7. **Repeat all steps for creating other network segments, but to allow communication between devices in the same VLAN but connected to different routers, connect the routers using Serial DCE cables through their serial ports and ensure that the VLAN has been added as a sub-interface in both routers.**

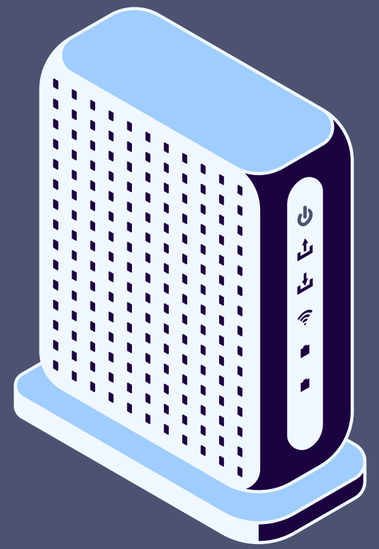


IMPLEMENTATION




```
Device Name: Router3
Device Model: 1941
Hostname: Router

Port                    Link   VLAN   IP Address
GigabitEthernet0/0      Up     --     <not set>
GigabitEthernet0/0.14   Up     --     192.168.14.1/24
GigabitEthernet0/1      Down   --     <not set>
```

```
Device Name: Router2
Device Model: 1941
Hostname: Router

Port                    Link   VLAN   IP Address
GigabitEthernet0/0      Up     --     <not set>
GigabitEthernet0/0.13   Up     --     192.168.13.1/24
GigabitEthernet0/0.14   Up     --     192.168.14.1/24
GigabitEthernet0/0.15   Up     --     192.168.15.1/24
GigabitEthernet0/1      Up     --     <not set>
```



TROUBLESHOOTING

Connection between switches:

- Devices could not ping others in the same VLAN when connected to different access switches.
- Cause: Access switches lacked the same VLAN(s) in their VLAN database.

Connection between routers:

- Devices on the same VLAN could not ping each other.
- Cause: Core switches were connected to different routers, with one router missing a subinterface for the VLAN.

Solutions:

- Ensure all necessary VLANs are present in the VLAN database of access switches.
- Verify routers have subinterfaces for VLANs requiring communication.

TROUBLESHOOTING

Minor Technical Issues:

- Ports not being enabled.
- Devices not using DHCP, resulting in a lack of IP addresses and DNS settings.

CONCLUSION

Network Design Achievements:

- Successfully segments the campus network logically while enabling communication between devices in the same VLAN across different access points.
- VLANs are compiled in core switches and relayed to access switches for proper device connectivity.
- Routers connected via serial cables allow communication between devices in different buildings or floors.

CONCLUSION

Areas for Improvement:

Firewall Rules:

- Absence of firewall rules compromises data confidentiality, integrity, and accessibility.
- Implementing firewall rules with gateways on router subinterfaces can enhance security and access control.

Core Switch Connections:

- Current use of GigabitEthernet0/0 ports should be replaced with GigabitEthernet0/0/0 for better modularity and future scalability.

Connection Type:

- Serial connections used between routers are slower and suited for WANs, not LANs.
- Ethernet connections are recommended for faster data speeds and better LAN management.