Campus Network Design & Implementation

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PROJECT SUBMITTED IN THE PARTIAL OF THE DEGREE OF BACHELOR OF SCIENCE IN COMPUTER SCIENCE AND ENGINEERING

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BANGLADESH

September, 2023

DECLARATION

I am M. M. Jahid Hasan declare that this project titled, **"Campus Network Design and Implementation"** submitted to the Patuakhali Science and Technology University, for the award of the Bachelor of Science in Computer Science and Engineering degree, is my original work. I have not plagiarized or submitted the same work for the award of any other degree. In-case this undertaking found an incorrect, I accept that my degree may be unconditionally withdrawn.

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DEDICATION

I dedicate this project to Almighty Allah our creator, our strong pillar, our source of inspiration, wisdom, knowledge and understanding. I dedicate my dissertation work to late mother, my elder brother as well as my other family members and my course teachers.

LETTER OF APPROVAL

The project titled “Campus Network Design and Implementation”, submitted by M. M. Jahid Hasan, Registration No. 07595, Roll No. 1702025 Session: 2017-18 to the Faculty of Computer Science and Engineering, Patuakhali Science and Technology University, has been accepted and satisfactory for the fulfilment of the requirement for the degree of Bachelor of Science in Computer Science and Engineering and approved as to its style and contents.

Approved

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ACKNOWLEDGEMENT

In the beginning, I want to give strongly thank to All-powerful Allah for being able to develop my project with His grace. Now I would relish to take the opportunity to express our humble gratitude to my dignified supervisor Prof. Dr. Md. Samsuzzaman, Department of Computer and Communication Engineering for his orchestrated and construction guidance at a different stage of this project work. It might have been quite infeasible to carry out this work without his guidance. I cannot forget his avail in the faculty of Computer Science & Engineering for the academic interactions and conceptions. Lastly, I would relish to convey my gratitude to all the edifiers of the Department of CSE Faculty for their guidance, companionship, discipline, and engendering an environment of exuberance for learning, appreciation for growing along the way. I am profuse of gratitude to have all of you as a guide. May Allah mystically enchant them and bulwark them.

With Best Regards,

M. M. Jahid Hasan

ABSTRACT

Networking is referred as connecting computers electronically for the purpose of sharing information. The aim was to design a network with high security. Resources such as a file, application, printers & software are some common information shared in a networking. The advantages of networking can be seen clearly in terms of security, efficiency, manageability & a cost effective which allows to collaborate with wide range. The Switches and Router this device that play an important role in data transfer from one place to another using different technology such as a radio waves & wire. LAN is a Local Area network which is made up of two or more computers connected together in a short distance usually at home, offices buildings or school. WAN is a Wide Area network that covers wider area than LAN and usually covers cities, countries and the whole world. Sometimes several major LAN can be connected together to form a WAN. AS a several devices are connected to network, it is important to ensure data collision does not happen when this device attempt to use data channel simultaneously. A set of rules called collision detection are used to detect and prevent collision in networks. This project is to design a suitable network system for universities, schools and companies. The aim was to design a network with high security. This project will help to enhance knowledge and learn different things of developing countries. The advantages of networking can be seen clearly in terms of efficiency, security, manageability and cost as it allows collaboration between users in a wide area. To improve campus network design, the technology used was creating LAN, WAN, VLAN and cheap device to reduce cost of the network. But the network can also become better using routing protocols and other protocol. So, we are going to use such protocols using a smaller number of devices and will also maintain the cost of the network less. To design such network, we used software Cisco-Packet Tracer. The implementation of this project with proper hardware connection has been done in this semester. This includes different hardware components.

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CHAPTER I
INTRODUCTION

1.1 Introduction

The word “digital” is very significant in today’s world, with an increase in the development of technology the entire world is moving towards the digital era. The educational institution plays an important role in this digitalization; hence the campus should adapt to digital means of networking as well and become a “digital campus”. Going wireless plays an important role in this digitalization. The wireless network makes the connection easy with a reduction in the use of wires or cables. A wired connection makes it difficult to keep track of all the devices and to manage the cable connection, which is not only chaotic but also challenging to handle.

Campus networking via wireless connection becomes an important part of campus life and provides the main way for teachers and students to access educational resources, which gives an important platform to exchange information. As laptops and intelligent terminals are widely used, demand for access to information anytime and anywhere has become more and more urgent, but traditional cable networks cannot meet this requirement. Then wireless network construction becomes necessary and essential. The wireless network is one of the important components of a digital campus and wisdom campus. It provides an efficient way to explore the internet with a mobile terminal for teachers and students regardless of cables and places.

This is an important mark of the modern campus as a supplement of a cable network. With the development of network and communication technology, cable networks on a university campus bring much convenience for teaching and research work. But for mobility and flexibility, it has obvious shortcomings. A wireless network can overcome these drawbacks and has been applied to the university campus.

1.2 Project Statement

In this mini-project, we defined a simulation of campus networks based on wireless networking. The network is divided into two sets: one for the campus area and the other for the hostel area.

The major aim of this project is to show the wireless connectivity that is used in universities to make the network efficient and mobile at the same time. Mobility is the major concentration of this project. In order to provide equal functionality to all the users (college staff and students), we have added DNS, Email, and HTTP servers for the maximum utilization of resources. Also, we have added some protocols like BGP, OSPF for better security purposes.

Hence the campus network provides different services such as connecting the user to the internet, data sharing among users (students, teachers, and different university members/stuff), accessing different web services for different functionalities, so it needs wireless networking for smooth processing.

CHAPTER II
LITERATURE SURVEY

2.1 Packet Tracer

Packet Tracer is a cross-platform visual simulation tool designed by Cisco Systems that allows users to create network topologies and imitate modern computer networks. The software allows users to simulate the configuration of Cisco routers and switches using a simulated command-line interface. Packet Tracer makes use of a drag-and-drop user interface, allowing users to add and remove simulated network devices as they see fit. The software is mainly focused on Certified Cisco Network Associate Academy students as an educational tool for helping them learn fundamental CCNA concepts. Previously students enrolled in a CCNA Academy program could freely download and use the tool free of charge for educational use.

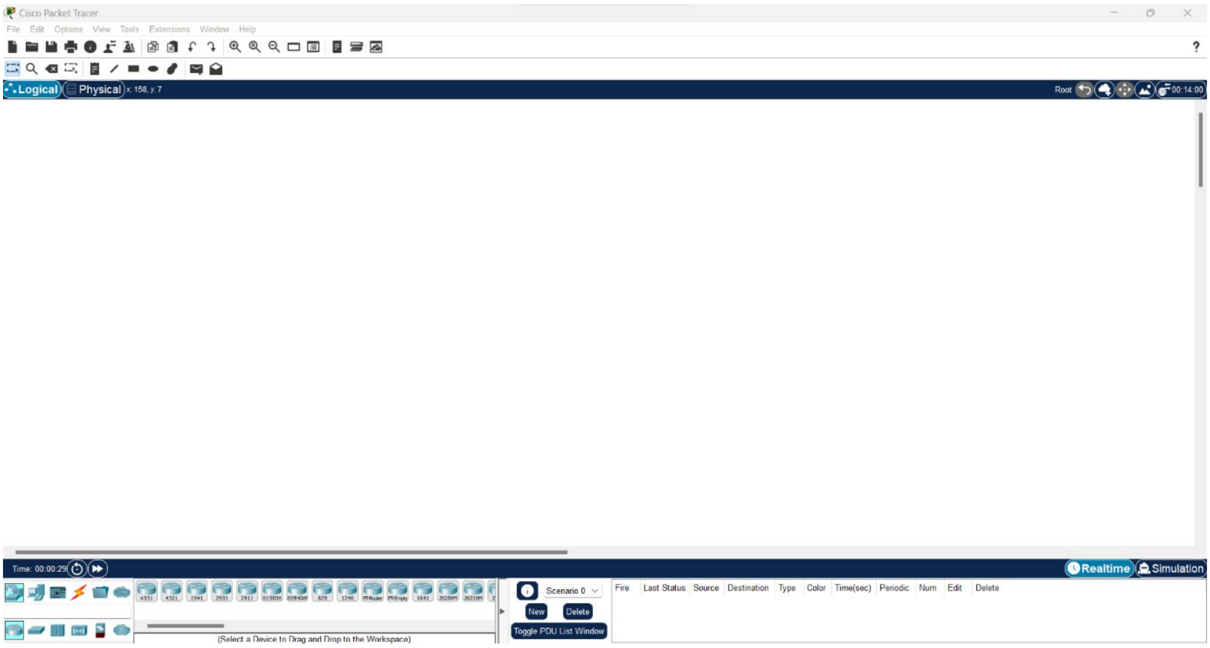

Figure 2.1: Cisco Packet Tracer

2.2 Hardware Components

- **Router**

  A router is a device like a switch that routes data packets based on their IP addresses. The router is mainly a Network Layer device. Routers normally connect LANs and WANs together and have a dynamically updating routing table based on which they make decisions on routing the data packets. Router divides broadcast domains of hosts connected through it. The routers we are using in this project are:

Figure 2.2: Mikrotik Core router CCR1016-12S-1S+

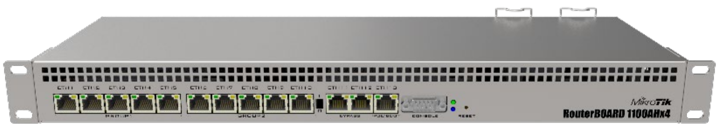

Figure 2.3: Mikrotik Router Board (1100AHx4)

Figure 2.4: ASUS RT-ACRH17

- **Switch**

A network switch (also called switching hub, bridging hub, officially MAC bridge is networking hardware that connects devices on a computer network by using packet switching to receive and forward data to the destination device. A network switch is a multiport network bridge that uses MAC addresses to forward data at the data link layer (layer 2) of the OSI model. Some switches can also forward data at the network layer (layer 3) by additionally incorporating routing functionality. Such switches are commonly known as layer-3 switches or multilayer switches.

The switch we are using for this project:

Figure 2.5: Cisco 28p Gigabit PoE Managed Switch

- **Cables**

Optical Fiber

A fiber-optic cable, also known as an optical-fiber cable, is an assembly similar to an electrical cable but containing one or more optical fibers that are used to carry light. The optical fiber elements are typically individually coated with plastic layers and contained in a protective tube suitable for the environment where the cable is used. Different types of cable are used for optical communication in different applications, for example, long-distance telecommunication or providing a high-speed data connection between different parts of a building.

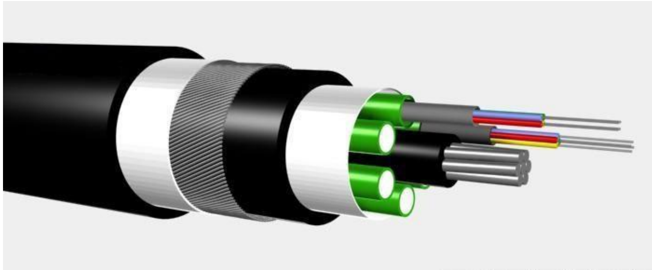

Figure 2.6: Optical Fiber

Cat 6 Cable

Category 6 cable (Cat 6) is a standardized twisted pair cable for Ethernet and other network physical layers that is backward compatible with the Category 5/5e and Category 3 cable standards. Cat 6 must meet more stringent specifications for crosstalk and system noise than Cat 5 and Cat 5e. The cable standard specifies performance of up to 250 MHz, compared to 100 MHz for Cat 5 and Cat 5e.

Whereas Category 6 cable has a reduced maximum length of 55 meters (180 ft) when used for 10GBASE-T, Category 6A cable is characterized to 500 MHz and has improved alien crosstalk characteristics, allowing 10GBASE-T to be run for the same 100-metre (330 ft) maximum distance as previous Ethernet variants.

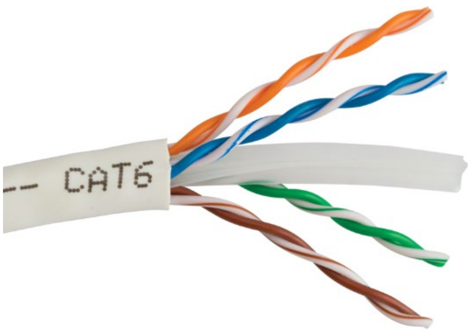

Figure 1.7: Cat 6 Cable

- **Small Form-factor Pluggable (SFP)**

Small Form-factor Pluggable is a compact, hot-pluggable network interface module format used for both telecommunication and data communications applications. An SFP interface on networking hardware is a modular slot for a media-specific transceiver, such as for a fiber-optic cable or a copper cable.

Figure 2.8: SFP Module

2.3 Network Packet

A network packet is a formatted unit of data carried by a packet-switched network. A packet consists of control information and user data, which is also known as the payload.

2.4 Wireless Network

A wireless network broadcasts an access signal to the workstations or PCs. This enables mobility among laptops, tablets, and PCs from room to room while maintaining a firm network connection continuously. A wireless network also presents additional security requirements.

2.5 Server

A server is a computer or system that provides resources, data, services, or programs to other computers, known as clients, over a network. In theory, whenever computers share resources with client machines, they are considered servers. There are many types of servers, including web servers, mail servers, and virtual servers.

Many networks contain one or more of the common servers. The servers used in our project are as follows:

- **DNS Server**

  DNS stands for Domain Name System servers which are application servers that provide a human-friendly naming method to the user computers in order to make IP addresses readable by users. The DNS system is a widely distributed database of names and other DNS servers, each of which can be used to request an otherwise unknown computer name. When a user needs the address of a system, it sends a DNS request with the name of the desired resource to a DNS server. The DNS server responds with the necessary IP address from its table of names.

- **Web Server**

One of the widely used servers in today's market is a web server. A web server is a special kind of application server that hosts programs and data requested by users across the Internet or an intranet. Web servers respond to requests from browsers running on client computers for web pages, or other web-based services.

- **Email Server**

An e-mail server is a server that handles and delivers e-mail over a network, using standard email protocols. For example, the SMTP protocol sends messages and handles outgoing mail requests. The POP3 protocol receives messages and is used to process incoming mail. When you log on to a mail server using a webmail interface or email client, these protocols handle all the connections behind the scenes.

2.6 Ethernet

This is the backbone of our network. It consists of the cabling and is typically able to Transfer data at a rate of 100mb/s. It is a system for connecting a number of computer systems to form a local area network, with protocols to control the passing of information and to avoid simultaneous transmission by two or more systems. Among the different types of ethernet, we have used Gigabit Ethernet, which is a type of Ethernet network capable of transferring data at a rate of 1000 Mbps and fast Ethernet is a type of Ethernet network that can transfer data at a rate of 100 Mbps.

2.7 Internet Protocol

Internet Protocol (IP) is one of the fundamental protocols that allow the internet to work. IP addresses are a unique set of numbers on each network and they allow machines to address each other across a network. It is implemented on the internet layer in the IP/TCP model.

2.8 Dynamic Host Configuration Protocol (DHCP)

Dynamic Host Configuration Protocol (DHCP) is a client/server protocol that automatically provides an Internet Protocol (IP) host with its IP address and other related configuration information such as the subnet mask and default gateway.

Every device on a TCP/IP-based network must have a unique unicast IP address to access the network and its resources. Without DHCP, IP addresses for new computers or computers that are moved from one subnet to another must be configured manually; IP addresses for computers that are removed from the network must be manually reclaimed. With DHCP, this entire process is automated and managed centrally. The DHCP server maintains a pool of IP addresses and leases an address to any DHCP-enabled client when it starts up on the network. Because the IP addresses are dynamic (leased) rather than static (permanently assigned), addresses no longer in use are automatically returned to the pool for reallocation.

2.9 Border Gateway Protocol (BGP)

BGP (Border Gateway Protocol) is the protocol underlying the global routing system of the internet. It manages how packets get routed from network to network through the exchange of routing and reachability information among edge routers. BGP directs packets between autonomous systems (AS), which are networks managed by a single enterprise or service provider. Routing protocol used between Internet service providers (ISP) and their larger private clients to exchange routing information.

Each router maintains a routing table controlling how packets are directed. Routing table information is generated by the BGP process on the router, based on incoming information from other routers, and information in the BGP routing information base (RIB), which is a data table stored on a server on the BGP router. The RIB contains information both from directly connected external peers, as well as internal peers, and based on policies for what routes should be used and what information should be published, continually updates the routing table as changes occur.

2.10 Open Shortest Path First (OSPF)

OSPF is type of hierarchical network topology or design. OSPF prefers fastest path rather than shortest path. In Open Shortest Path First, internet protocol is used. It uses link-state-routing (LSR) algorithm for its functionality.

OSPF is an Interior Gateway Protocol (IGP), where routers connect networks using the Internet Protocol (IP). It is a router protocol which is used to find the best path for packets when they are passing through the set of connected networks simultaneously. The main disadvantage of OSPF is that it is difficult than other protocols.

CHAPTER III
METHODOLOGY

Successful projects are well managed. To manage a project efficiently, we must have to choose the software development methodology that will work best for our project. All methodologies have different strengths and weaknesses and exist for different reasons. Here's an overview of the methodology approach we have use for our project.

3.1 Hierarchical design model

The hierarchical network design model breaks the complex flat network into multiple smaller and more manageable networks. Each level or tier in the hierarchy is focused on a specific set of roles. This design approach offers network designers a high degree of flexibility to optimize and select the right network hardware, software, and features to perform specific roles for the different network layers.

The network will be divided into three main areas:

- **Core layer:** Provides optimal transport between sites and high-performance routing. Due the criticality of the core layer, the design principles of the core should provide an appropriate level of resilience that offers the ability to recover quickly and smoothly after any network failure event with the core block.
- **Distribution layer:** Provides policy-based connectivity and boundary control between the access and core layers.
- **Access layer:** Provides workgroup/user access to the network. The two primary and common hierarchical design architectures of enterprise campus networks are the three-tier and two-tier layers models.

3.2 The reason to choose Hierarchical design model

The chief benefit of three-tier architecture is that because each tier runs on its own infrastructure, each tier can be developed simultaneously by a separate development team, and can be updated or scaled as needed without impacting the other tiers.

Other benefits (compared to single- or two-tier architecture) include:

- Improved scalability: Any tier can be scaled independently of the others as needed.
- Improved reliability: An outage in one tier is less likely to impact the availability or performance of the other tiers.
- Improved security: Because the presentation tier and data tier can't communicate directly, a well-designed application tier can function as a sort of internal firewall, preventing SQL injections and other malicious exploits.

CHAPTER IV
PROJECT IMPLEMENTATION

4.1 Software Requirements

- **Software**
  - Cisco Packet Tracer 8.2
  - WinBox 3.37 (64 bit)
  - Chrome/Firefox Browser
- **Operating Systems**
  - Windows 11 Pro
  - CentOS 8.2
  - LibreOffice

4.2 Hardware Requirements

- Mikrotik Core router (CCR1016-12S-1S+)
- Mikrotik Router Board (1100AHx4)
- Cisco 28p Gigabit PoE Managed Switch
- SFP 1.25G-BIDI-SC20
- Optical fibres
- Cat 6 cables
- ASUS RT-ACRH17 Router
- Mobile phones
- Laptops/computers with proper specifications

4.3 Network Requirements

Our campus network design has four layers to complete. They are,

- ISP Layer
- Core Layer
- Distribution Layer
- User Access Layer

Devices Used in The Network:

Table 1: Devices names and quantity

Devices	**Quantity**
Router (PT-Empty)	2
Router (WRN300N)	3
Switch (2950)	4
Switch - PT	1
Server - PT	1
PC - PT	4
Laptop - PT	3

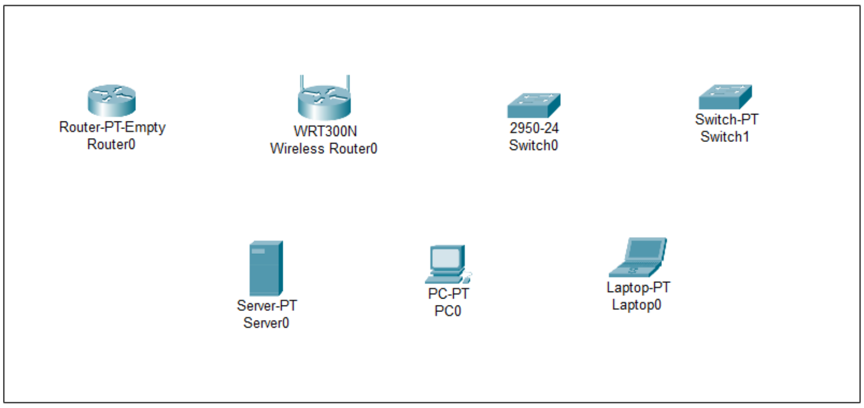

Figure 4.1: Devices used in the network

4.4 Implementation and Flow chart

To design the wireless network of the university we initially started by placing the core devices into the frame as mentioned in the layout.

- Firstly, we placed the main router at the centre of the university outline, which was further connected to the server switch using the gigabit ethernet port with copper straight-through cable and sub routers using the serial port with serial DCE cable at the hall area and campus area respectively.
- The server switch was further connected to the DNS and WEB servers respectively.
- Campus router was connected to the campus switch which was further connected with wireless access points of the academic block.
- The wireless access points were then connected to computing devices (PCs, laptops, and smartphones).
- Similarly, the hall router was connected to the hall switch which was further connected with the wireless access point of boy's block and girl's block.

- The wireless access points were then connected to the computing devices (PCs, laptops, and smartphones), every area has a dedicated access point which can only be connected with the help of a password.
- All these connections are made through ethernet ports (gigabit ethernet and fast ethernet) using copper straight-through cables.

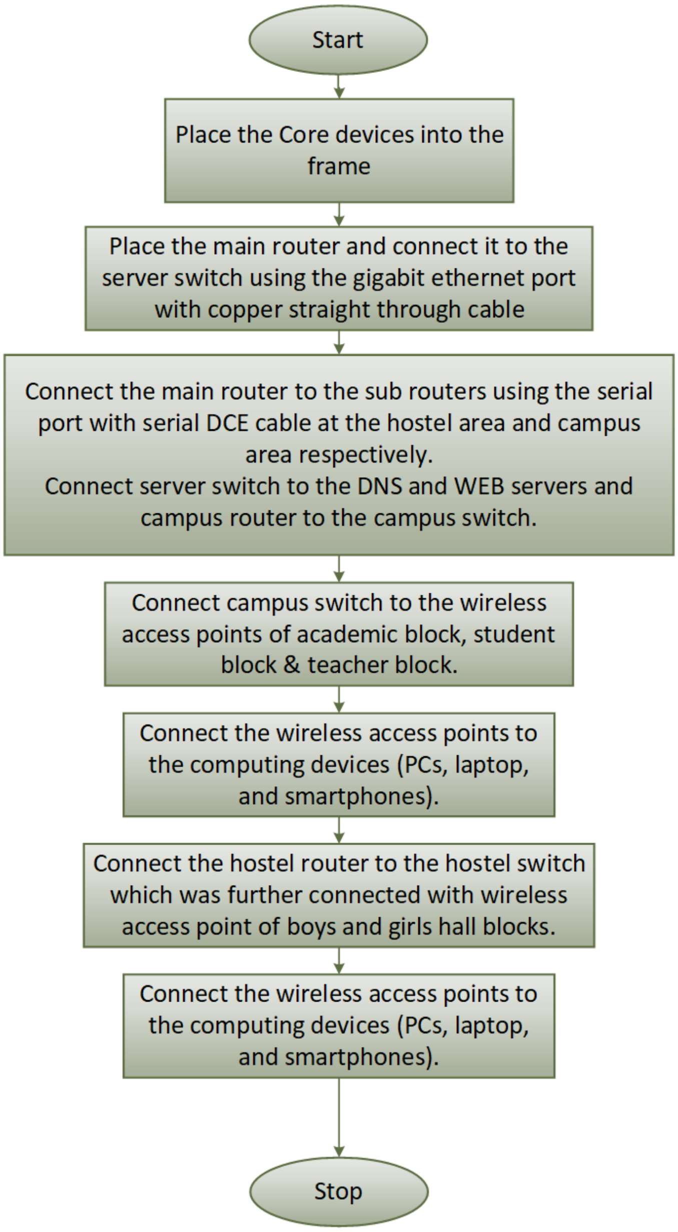

Figure 4.2: Campus network design model

This is the flow diagram for a better understanding of the steps mentioned above.

4.5 Configuring IP Addresses

Here is the IP configuration that has been done in Cisco Packet Tracer:

Table 2: Address table 1

Device/Endpoints	IP Address	Subnet Mask	Default Gateway	Network
ISP Public Network			103.133.254.1	103.133.254.0/24
Public DNS/HTTP Server	103.133.254.2	255.255.255.0	103.133.254.1	103.133.254.0/24
Remote PC	103.133.254.4	255.255.255.0	103.133.254.1	103.133.254.0/24
Core Router:				
Interface 1	103.133.254.1	255.255.255.0		103.133.254.0/24
Interface 2	10.28.0.1	255.255.255.248		10.28.0.0/29
Dist. Router:				
Interface 1	10.28.0.2	255.255.255.248		10.28.0.0/29
Interface 2:				
Sub-interface 10	10.28.32.1	255.255.224.0		10.28.32.0/19
Sub-interface 20	10.28.64.1	255.255.224.0		10.28.64.0/19
Sub-interface 30	10.28.96.1	255.255.224.0		10.28.96.0/19

Table 3: Address table 2

VLAN-ID & Name	DHCP Pool		Default Gateway	Network
	DHCP From	DHCP To		
VLAN-10 Student	10.28.32.2	10.28.63.254	10.28.32.1	10.28.32.0/19
VLAN-20 Teacher	10.28.64.2	10.28.95.254	10.28.64.1	10.28.64.0/19
VLAN-30 Academic	10.28.96.2	10.28.127.254	10.28.96.1	10.28.96.0/19

Table 3: Address table 3

SSID	Password
ABC_Student	987654321
ABC_Teacher	987654321
ABC_Academic	987654321

4.6 Overview in a snapshot

Finally, we have combined all the steps as mentioned and implemented the desired wireless network for a University Campus. We have the complete network providing various facilities to the teaching staff, non-teaching staff, and students.

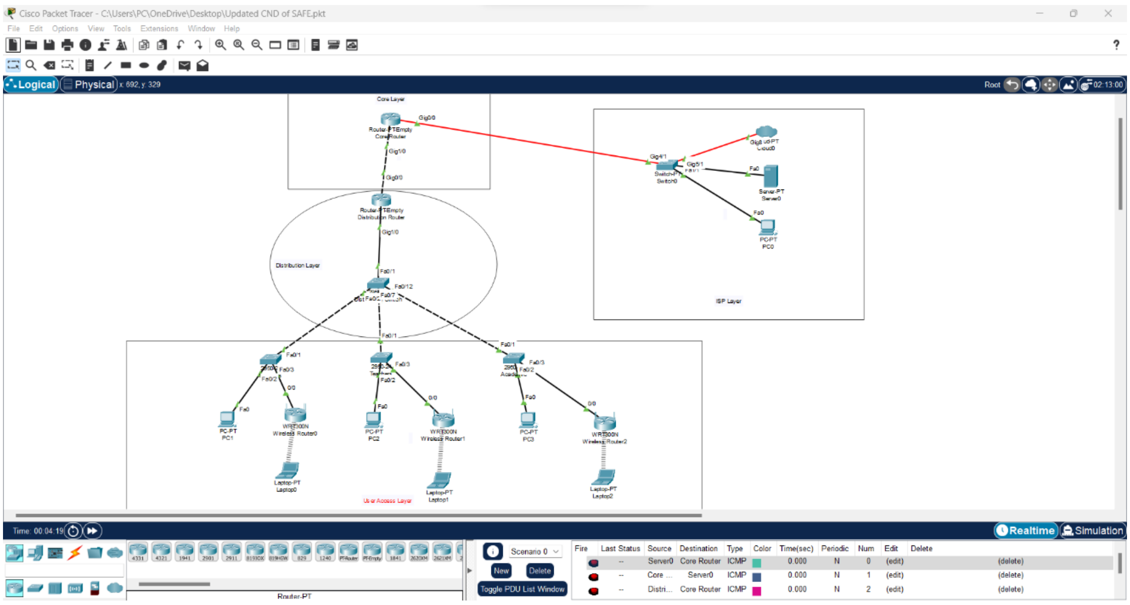

Figure 4.3: Campus network design using packet tracer

4.7 The project in real view

The final view of this project looks like this image.

Figure 4.4: Campus network design with hardware implementation

4.8 Total overview of the project

The simple overview of this project is going to look like this.

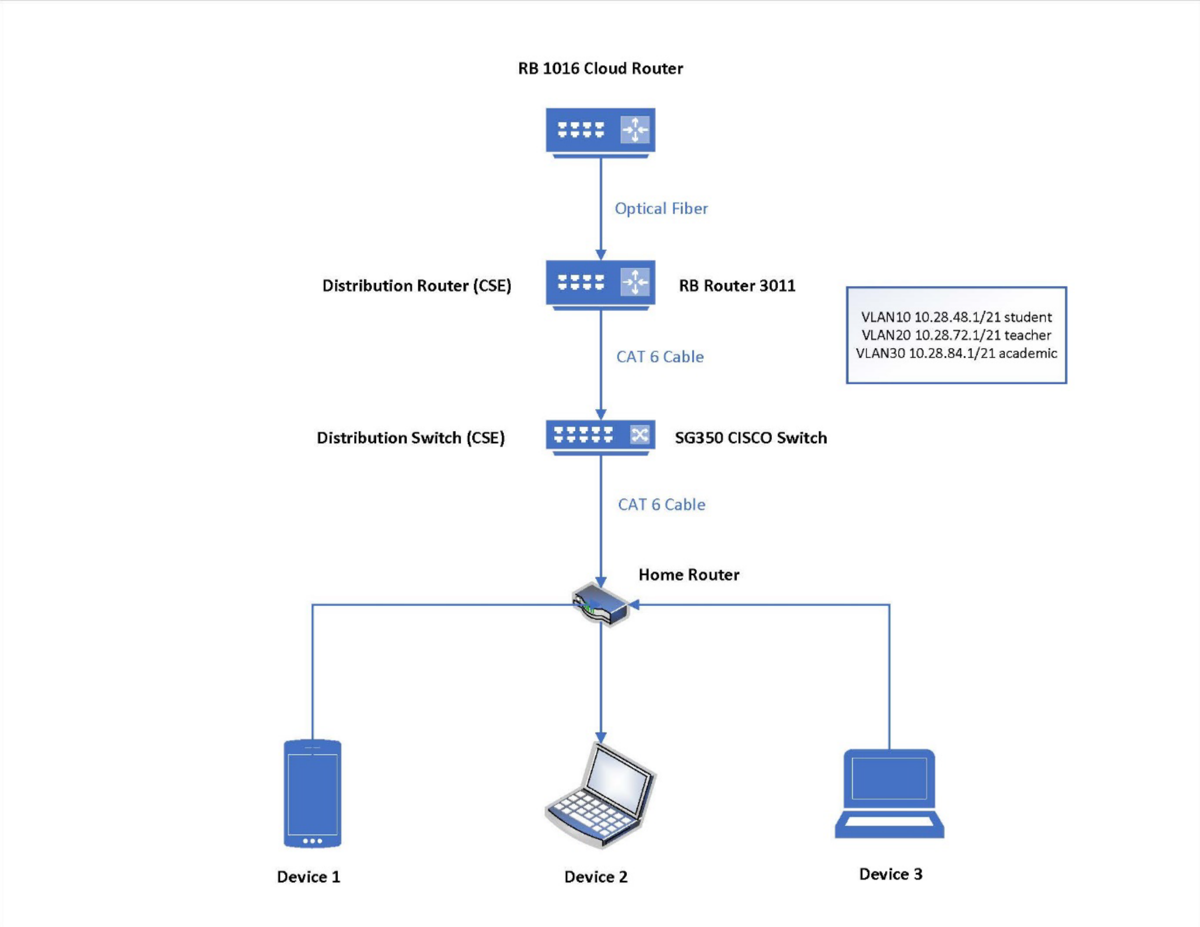

Figure 4.5: Overview of the project

4.9 Configuration snapshots

Here are some snapshots of configuration process.

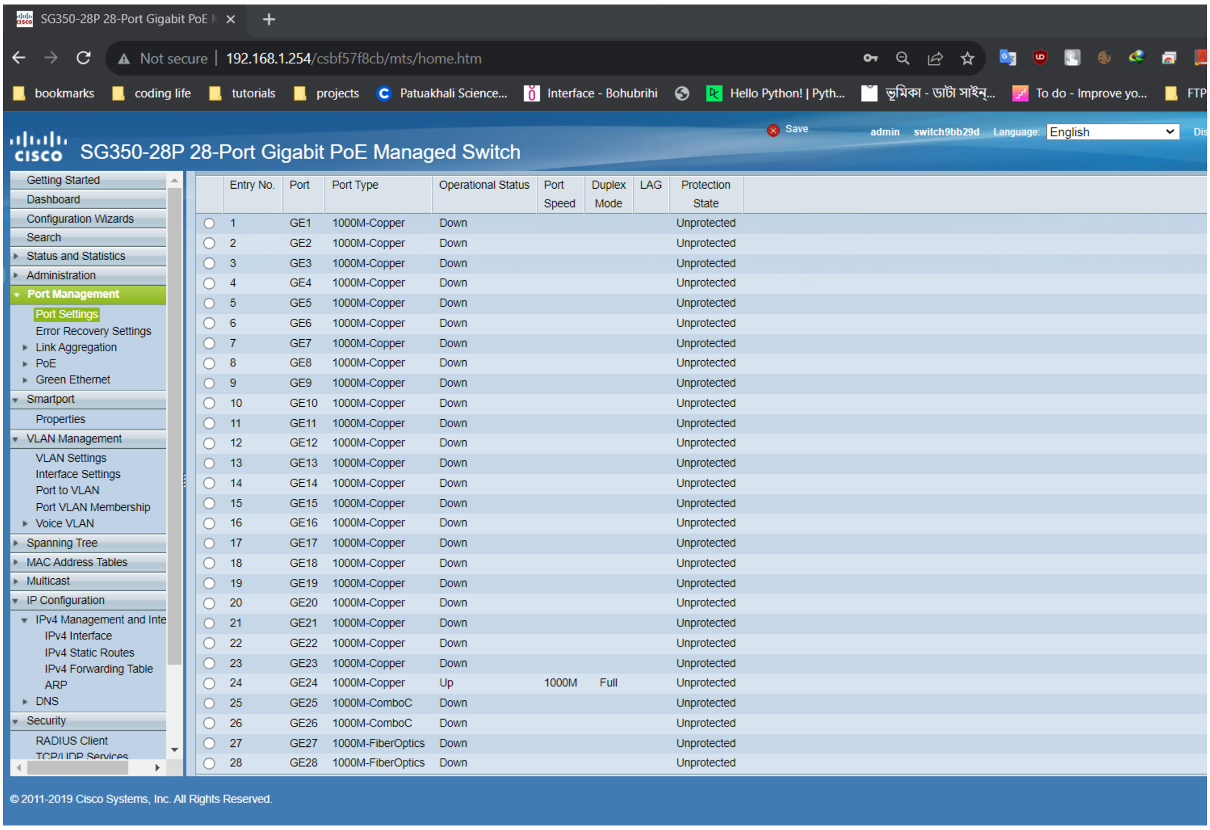

Figure 4.6: Distribution switch configuration

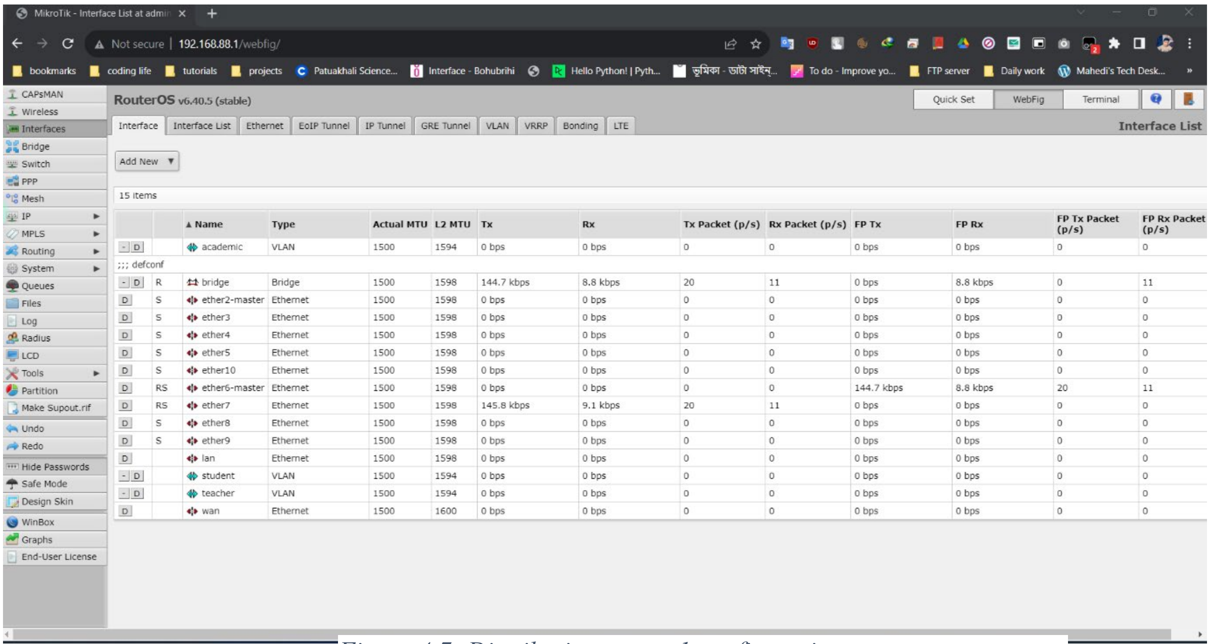

Figure 4.7: Distribution router 1 configuration

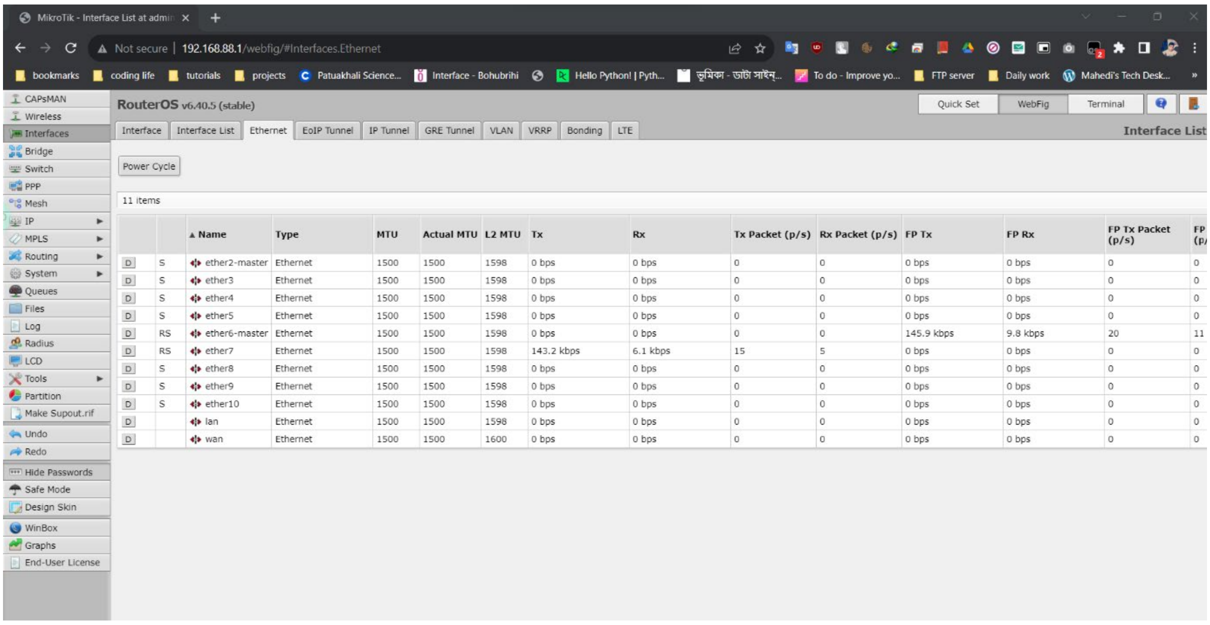

Figure 4.8: Distribution router 2 configuration

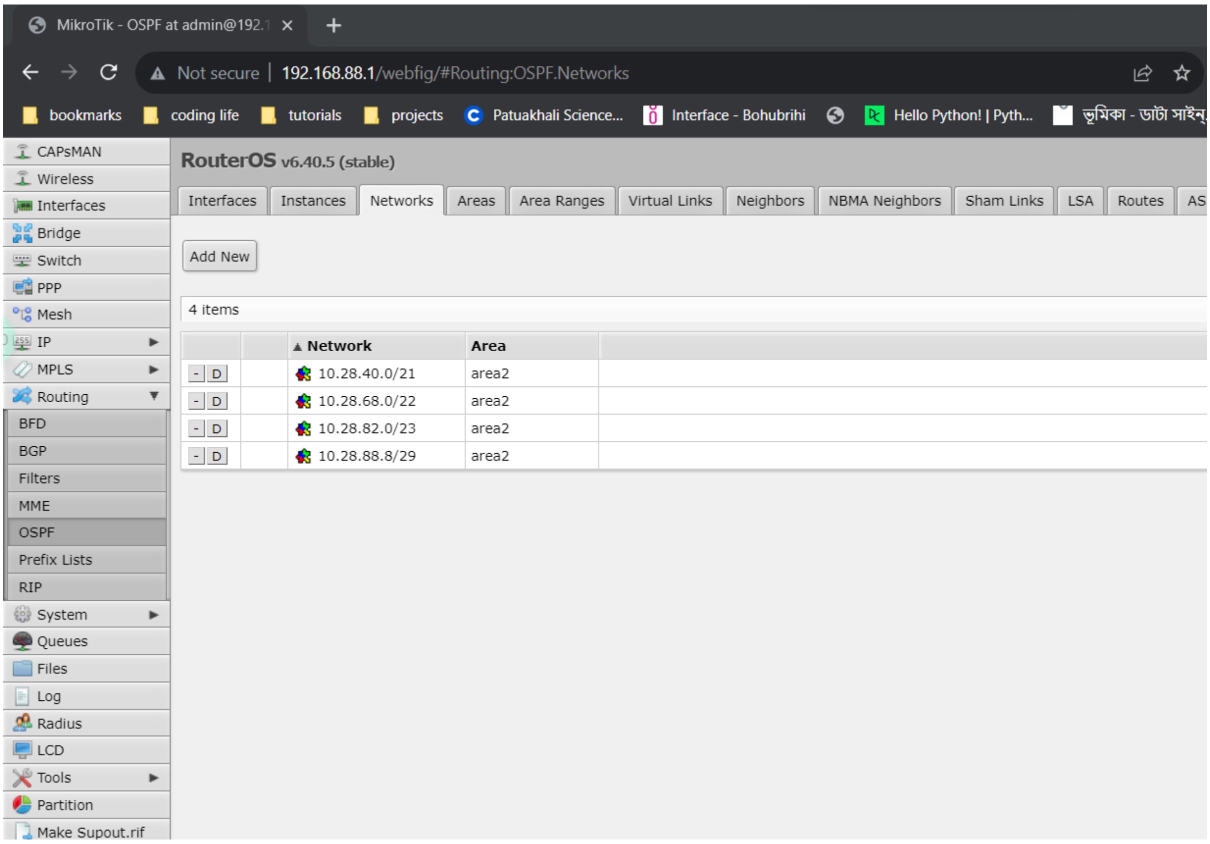

Figure 4.9: OSPF configuration

CHAPTER V
CONCLUSION

5.1 Conclusion

The implementation of the campus network using Cisco Packet Tracer and Mikrotik network devices will provide a reliable and efficient network for the staff and students. The use of hierarchical design and VLANs will provide scalability and security, while the wireless network will provide connectivity to mobile devices. The implementation will be tested and verified to ensure that it meets the requirements and specifications of the campus. The use of Mikrotik network devices will provide high-performance routing and firewall services, while the Cisco switches will provide reliable and efficient connectivity to individual devices. The use of Cisco firewall will ensure that the network is protected from external threats and unauthorized access.

Overall, the implementation of the campus network using Cisco Packet Tracer and Mikrotik network devices will provide a robust and scalable network that can meet the current and future needs of the campus. The network will provide reliable and efficient connectivity to different departments, staff, and students, which is essential for the smooth operation of the campus.

5.2 Future Work

Firstly, we should focus on Traffic Analysis and Optimization. It's important to implement network monitoring and analysis tools to continuously track traffic patterns and identify areas that may require optimization. Additionally, we can fine-tune our Quality of Service (QoS) policies to ensure that critical applications receive the necessary bandwidth and prioritize network traffic effectively.

Security remains a paramount concern. We need to evaluate and possibly implement additional security measures, such as intrusion detection systems (IDS) and intrusion prevention systems (IPS), to fortify our network against evolving threats. Regularly updating firewall rules and access control lists (ACLs) is also crucial to stay ahead of security challenges.

To enhance network resilience, we should consider High Availability (HA) configurations for critical network components to minimize downtime in case of hardware failures. Implementing link redundancy and load balancing can further ensure network reliability.

IPv6 integration is essential to future-proof our network, so we should plan and execute this integration carefully. Additionally, exploring advanced routing protocols like EIGRP or ISIS and their suitability for our network environment could be beneficial.

Automation and orchestration play a significant role in modern networking. Implementing network automation tools and scripts can streamline configuration and management tasks, while the adoption of software-defined networking (SDN) principles can enable more dynamic provisioning.

Thorough and up-to-date network documentation is a must, as it reflects any changes or additions to our network. Regular training for network administrators and staff ensures they stay current with best practices and new technologies.

For disaster recovery and business continuity, we need a comprehensive plan that covers backup and recovery procedures for network configurations and data. Regular testing of this plan is essential to guarantee its effectiveness.

Evaluating new vendors and technologies in the networking field should be an ongoing process. We need to stay informed about the latest advancements and assess if any could enhance our network's performance or security.

Compliance with industry regulations and standards is another critical consideration. Regular audits are necessary to verify our compliance and make any necessary adjustments.

User feedback and satisfaction are valuable. We should actively seek input from network users to identify pain points or areas for improvement in their network experience, using this feedback to make targeted enhancements.

Lastly, budget planning should align with our future network goals, ensuring that the resources allocated for maintenance and expansion are adequate and in line with our strategic objectives.

Prioritizing these future work items should be based on their importance to our overall network goals, resource availability, and organizational needs. Regularly reviewing and updating our network roadmap will help keep our campus network robust, efficient, and secure.

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