Multi-LAN Wireless Network Infrastructure

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Abstract

This project explores the design, development, and implementation of a large and multifaceted wireless network using Cisco Packet Tracer, focusing on the integration of three distinct LAN configurations: a cellular LAN, a WiFi system, and a wired network with a wireless router. The network architecture is designed to support 4G/5G connectivity, VoIP capabilities, and data transfer across all segments, making seamless communication between various devices, including smartphones, laptops, and VoIP phones. Through the use of Gateway/NAT routers, the network facilitates both external and internal connectivity, using IPv4 static public IP addresses for external access and private IPv4 addressing for internal communications, managed by dedicated DHCP servers within each LAN (LAN3 Server is not just a dedicated DHCP server)

A huge aspect of this project involves the implementation of security measures for each LAN type, addressing the challenges shown by cellular, WiFi, and wired networks. This project demonstrates the network's functionality through simulations, which shows the ability of mobile devices to perform voice and data communication. To add, the network's design incorporates two servers to facilitate a client/server exchange process, showing the network's capabilities in handling data and voice connectivity. The gritty details of the technical specifications and configurations of the proposed network are provided, and insight into the practical challenges and solutions encountered during the network's development are offered to conclude the project.

Introduction

The evolution of wireless networking has transformed the way we communicate, access information, and conduct business. With the invention of 4G and 5G technologies, the capabilities of networks have expanded, offering higher speeds, reduced latency, and increased connectivity. This project leverages Cisco Packet Tracer to design and implement a complex network system that encapsulates the essence of modern wireless communication through the integration of three distinct Local Area Networks (LANs): a cellular LAN, a Wireless LAN (WLAN), and a Wired LAN equipped with a wireless router. Each LAN is configured to support both voice and data transfer, simulating a real-world, multi-faceted network environment.

Problem Statement

The design and deployment of a network that integrates diverse technologies, such as cellular systems, WiFi, and wired networks with wireless capabilities, presents a large variety of challenges. These include ensuring great connectivity, seamless data, and voice communication across different network types, and maintaining security standards.

Objective

The primary objective of this project is to construct a comprehensive network within Cisco Packet Tracer that includes a cellular LAN, a WiFi system, and a wired LAN with wireless router capabilities. This network will exhibit 4G/5G architecture functionalities, VoIP capabilities, and efficient data transfer mechanisms. A significant goal is to ensure that each segment of the network is accessible through a Gateway/NAT router with IPv4 static public IP addresses externally and private IPv4 access internally. Additionally, the project aims to present the network's functionality by running simulations for voice and data transmission, emphasizing the security measures implemented across the different LANs to safeguard the network integrity.

Design and Development Process

Requirements

The project required the simulation of a 4G/5G network architecture capable of supporting VoIP and data transfer across three interconnected LANs. Each LAN was designed to facilitate both external and internal connectivity, utilizing IPv4 static public IP addresses for external access and private IPv4 addressing for internal communications. The inclusion of DHCP servers within each LAN ensured dynamic IP address allocation for internal devices, while security measures were tailored to each LAN's unique needs as outlined in the testing and results section.

Scope

The scope of this project extended to the configuration of three distinct LANs within Cisco Packet Tracer, each designed to demonstrate specific aspects of wireless networking:

A.) LAN 1: This LAN featured two cell towers and a central office server, supporting connectivity for three smartphones. The gateway router facilitated NAT functionality, connecting the LAN to external networks via a serial link.

B.) LAN 2: Comprising of three access points and a server, this LAN enabled wireless connectivity for five laptops and two smartphones. A switch and NAT were installed between the access points and the router/gateway to manage IP addressing.

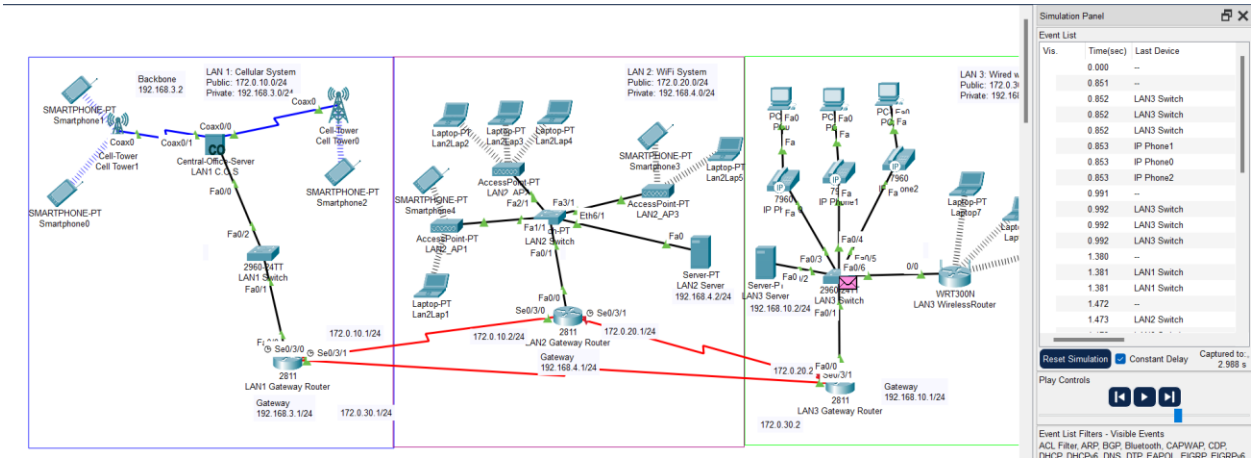
C.) LAN 3: This LAN connected three VoIP phones and three computers in series, with an additional three laptops connected via a wireless router. A VLAN was necessary to segregate the wired and wireless segments.

Technical Description of Project

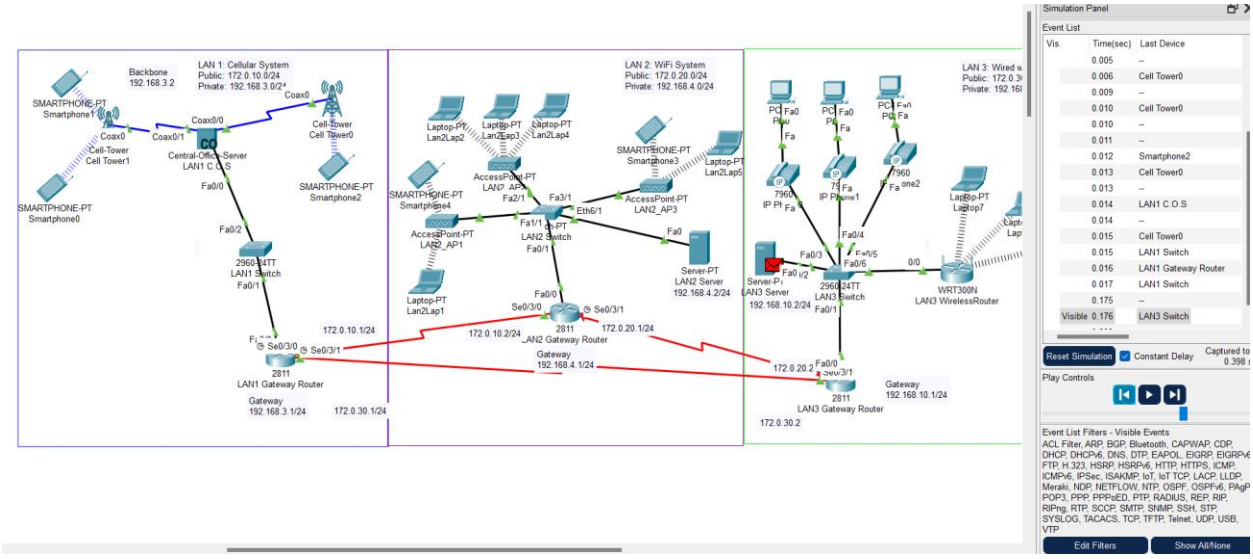
The network's architecture was carefully planned in order to ensure the seamless integration of the cellular, WiFi, and wired components. The gateway routers for each LAN were assigned IPv4 public IP addresses (172.0.10.1, 172.0.20.1, and 172.0.30.1) to facilitate external connectivity. On the internal side, DHCP servers assigned private IP addresses to devices, ensuring efficient network management and security. This included setting up servers, routers, switches, and access points, as well as configuring IP addressing and security settings. The gateway routers for each LAN were configured first, then servers and end devices/routers. Simulations were run to verify the connectivity and functionality of voice and data transmission across the network, demonstrating the successful integration of the three LANs.

Testing and Results

Data Transfer Simulation

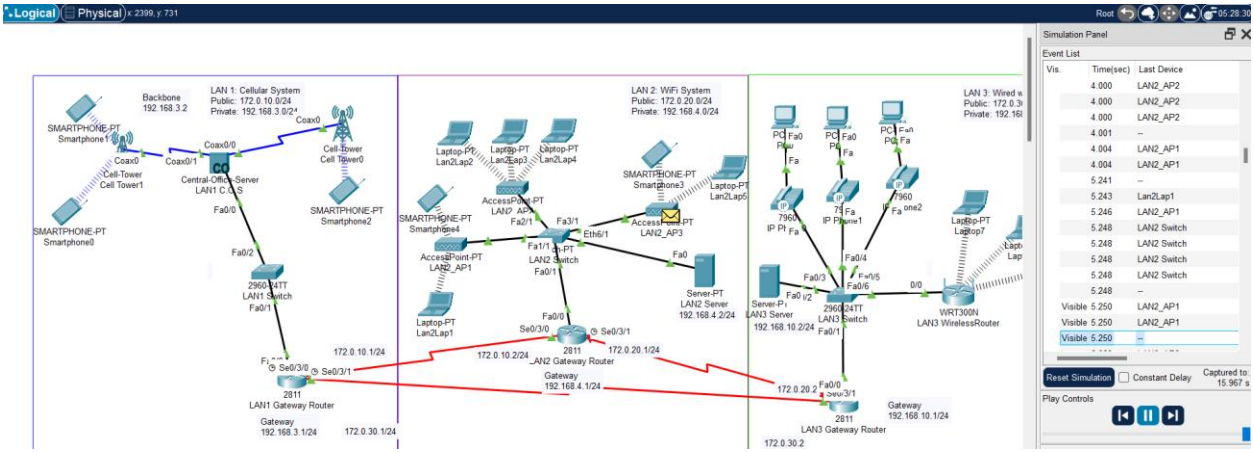


The first transfer was found to be successful from a PC located in LAN3 to the office server located in LAN1.



The second transfer was also found to be successful from a smartphone in LAN1 to the server located in LAN3.

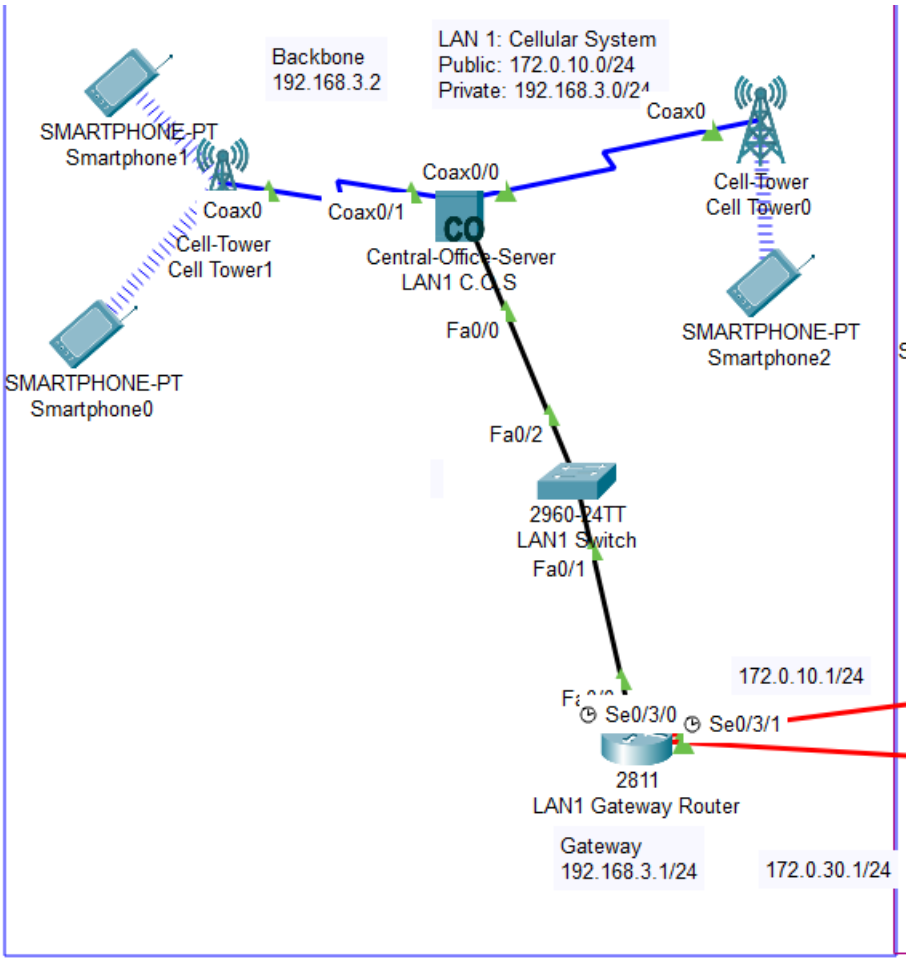
VoIP Simulation



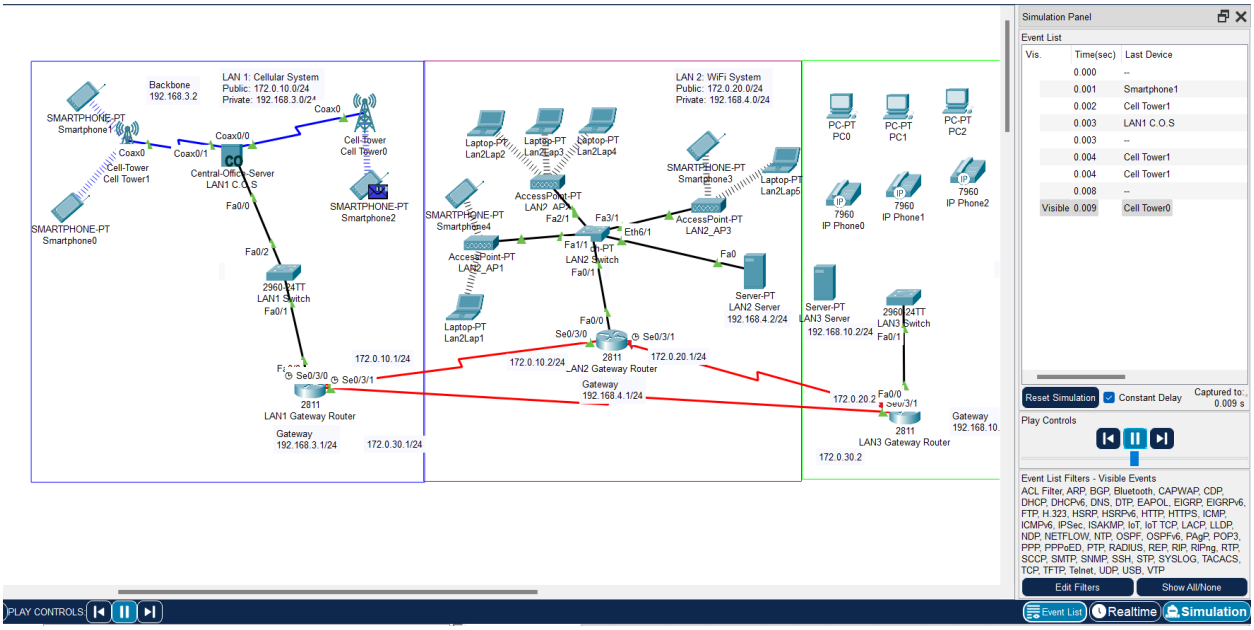
The initiation of a call when simulated worked perfectly when calling devices in other LANs. VoIP-related events were filtered to ensure VoIP worked correctly across all LANs.

LAN 1: Cellular System

This section features a cellular network system with a central office server (C.O.S) that connects to two cell towers through coaxial cables, offering wireless connectivity to three smartphones. The central office server likely provides DHCP services to assign IP addresses within the cellular network. The LAN 1 switch connects various components within this LAN and links to the LAN1 Gateway Router, which facilitates the external connectivity.

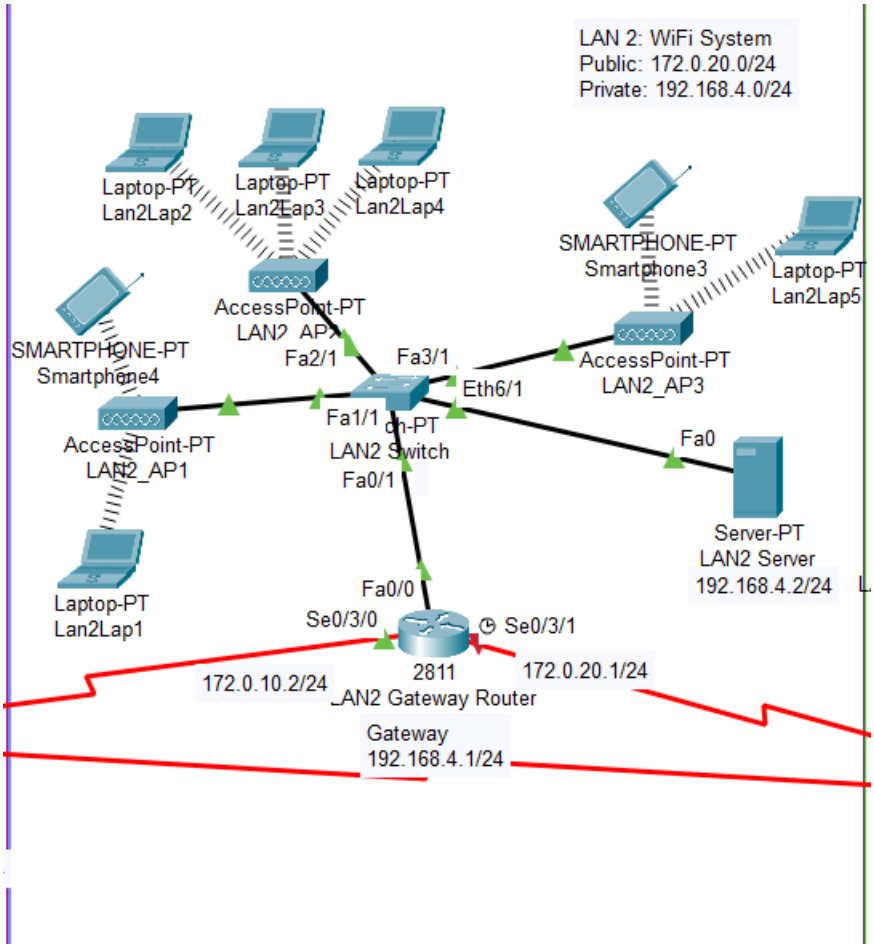


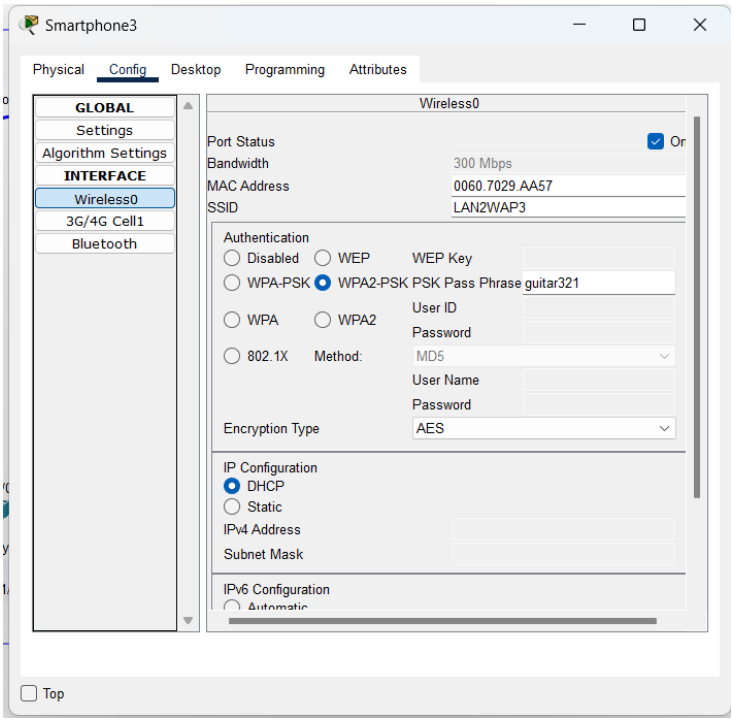
Once the topology and the connections between network devices and end devices, a smartphone from the cell tower on the left is to ping a cellphone corresponding to the cell tower on the right side of the topology.



LAN 2: WiFi System

The WiFi network consists of three wireless access points (WAPs), each providing wireless connectivity to multiple laptops and smartphones. These access points are wired to the LAN2 switch, which consolidates the wireless traffic and connects to the LAN2 Server and LAN2 Gateway Router. The server in this LAN also likely serves as a DHCP server, managing the IP configuration for the wireless devices.

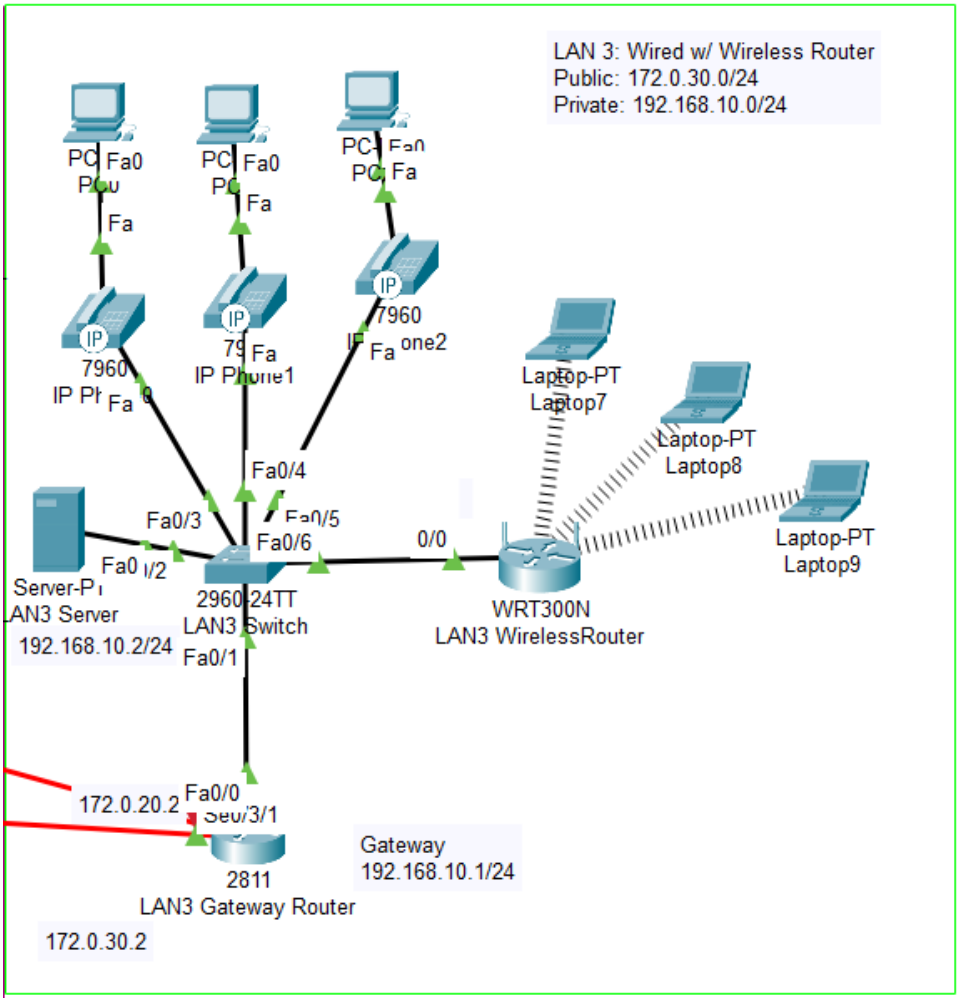




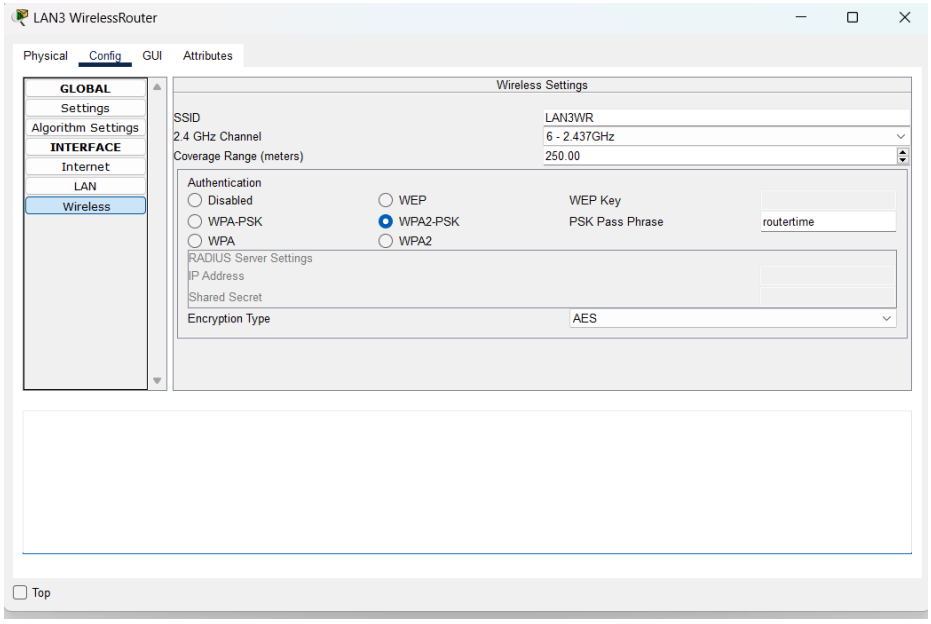
Now, the WPA2-PSK authentication for proper security measures needs to be enforced. Each access point in LAN2 has their own SSID and unique PSK Pass Phrase.

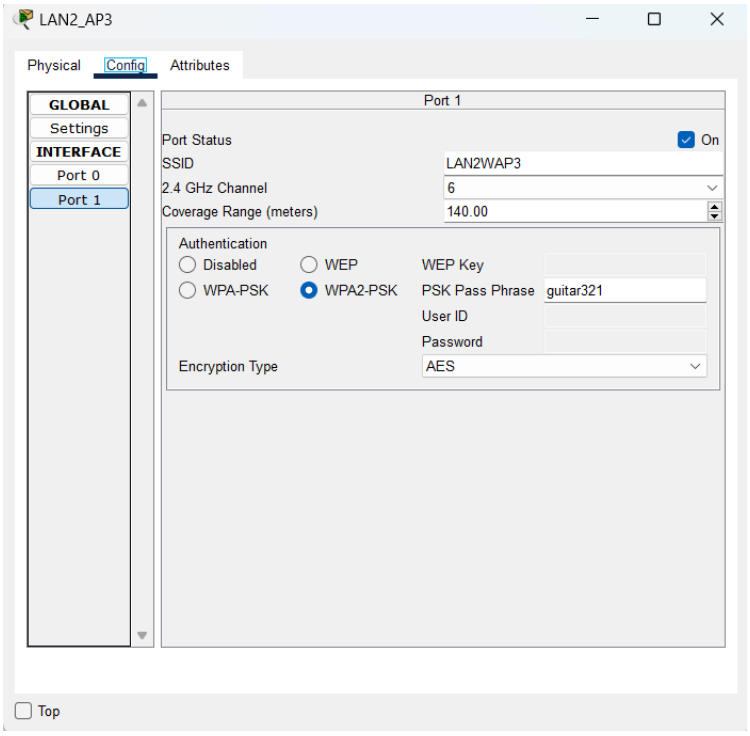
LAN 3: Wired with a Wireless Router

This LAN is a hybrid, with wired connections to PCs and IP phones, alongside a wireless segment for laptops. The IP phones are connected in series with the PCs, which in turn connect to the LAN3 switch. Also, the LAN3 Wireless Router provides wireless access for laptops 7-9. The LAN3 Server is connected to the switch and provides network services, including DHCP for IP address assignments within this LAN.



The LAN3 Wireless Router is set with a SSID and WPA2-PSK authentication method.





Summary

The project's objective was to design and implement a multi-layered network system utilizing Cisco Packet Tracer, integrating a cellular system (LAN 1), a wireless LAN (LAN 2), and a wired network with wireless router capabilities (LAN 3). Each segment was configured to support both voice and data transmission, leveraging a 4G/5G architecture. The comprehensive network facilitated communication between various devices, including smartphones, laptops, and VoIP phones, through interconnected access points and DHCP servers assigned to each LAN. Security measures were tailored to the network type to emulate a real-world secure environment through utilization of SSID's, WPA2-PSK, and more.

Conclusion

The successful configuration and simulation of the network illustrated the practical application of complex networking concepts. This project has demonstrated that each LAN could support its designated data and voice traffic effectively, with LAN 1 providing cellular connectivity, LAN 2 offering wireless access, and LAN 3 delivering wired connections with wireless access points for mobile devices.

It also showed interconnectivity between LANs was achieved through gateway routers using static IPv4 public IP addresses for external communication, while internal devices relied on private IPv4 addressing provided by DHCP servers. Next, the simulation scenarios confirmed that the network could handle voice calls and data transfers simultaneously without compromising performance or security, validating the robustness of the design.

The VLAN implementation on LAN 3 served to segregate traffic efficiently, ensuring the smooth operation of both data and VoIP services. After the VLAN implementation, the

client/server exchange process was clearly demonstrated by at least two servers within the network, evidencing the network's capability to handle typical enterprise data workflows. Finally, connectivity paths for data transfer and VoIP communication were well-defined, with simulations showcasing the seamless integration of different technologies and protocols to achieve a harmonious network operation.

References

ComputerNetworkingNotes. (2023, December 18). *How to configure wireless network in packet tracer*. ComputerNetworkingNotes. https://www.computernetworkingnotes.com/ccna-study-guide/how-to-configure-wireless-network-in-packet-tracer.html

How to configuring a cell tower on central office server (packet tracer). Cisco Community. (2022, December 6). https://community.cisco.com/t5/routing/how-to-configuring-a-cell-tower-on-central-office-server-packet/td-p/3833022

Packet tracer 8.1.1 tutorial - IP telephony basic configuration. Packet Tracer Network. (n.d.). https://www.packettracernetwork.com/tutorials/voipconfiguration.html