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Network Infrastructure Assessment: A Basis for Enhanced Network Design

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ABSTRACT: This study presents an assessment and proposed upgrade of the network infrastructure at Cauayan City Hall with the goal of addressing existing hardware and software limitations and improving overall performance. The project incorporates the PPDOO approach, which is divided into several stages: Prepare, Plan, Design, Operate and Optimize The current network setup which includes insufficient printers, outdated routers, limited-port switches, and varying computer specifications, was found to contribute to inefficiencies and performance bottlenecks.The proposed design introduces a more robust system, incorporating advanced routers, managed switches, high-capacity printers, and strategically placed access points to enhance connectivity and support both wired and wireless devices. Additionally, the implementation of a tree topology network structure is recommended to replace the current star topology, improving scalability, reliability, and performance. Software updates, including enhanced security and productivity tools, will complement the hardware upgrades. Network performance will be optimized through the use of fiber-optic cabling, Wi-Fi 6 technology, VLANs, and DHCP for IP management, ensuring better bandwidth distribution and minimizing congestion. The study emphasizes the importance of network security through port security and VLAN configurations and highlights the need for skilled personnel to manage and maintain the upgraded system. Overall, the proposed network infrastructure is designed to meet the growing demands of City Hall's operations, ensuring reliable and scalable connectivity, supporting future expansion, and enhancing overall network performance.

KEYWORDS: Network Infrastructure, Network Design, Network security.

CHAPTER 1
THE PROBLEM AND ITS BACKGROUND

Introduction

Every day a lot of transaction happens at Cauayan City Hall such as Business Permit, Licensing, Legal Services, Accounting, and more. The resilience of network infrastructure within public institutions has become a key foundation for guaranteeing efficient service and protection of sensitive data. As digital interfaces become more integrated into the day-to-day operation of public services, the importance of secure, dependable, and efficient network infrastructure cannot be understated. City Hall's network infrastructure assessment policy mandates unscheduled assessments to be conducted in response to events such as security incidents or significant network changes. Currently, City Hall's primary Internet Service Provider (ISP) is PLDT, which is crucial in delivering the necessary connectivity and network services for its operation.

In today's digital age, the efficiency of city operations heavily relies on the robustness of their IT infrastructure to support their wide range of services. Over time, the demands on this infrastructure have increased due to the growing reliance on digital services and the need for real-time data access and processing. However, without regular assessments and upgrades, network infrastructures can become outdated, leading to inefficiencies, security vulnerabilities, and disruptions in service delivery.

Among such institutions, City Hall stands out as a prominent administrative institution with a critical role in governance and service delivery to the community it serves. On 23-25 March 2023 City Isabela is awarded to be the first smart city. Being able to declare a smart city means having efficient and good networks and services with the utilization of digital solutions for the benefit of citizens and businesses (PCHRD, 2022). This study can contribute to maintaining the title of being a "Smart City" as risks and vulnerabilities in the network can be present day-to-day. Also, smart cities require high-speed, reliable communication networks to transmit data between devices, systems, and users.

Currently, City Hall faces challenges with its network performance, including slow data transfer rate, poor internet connection, and frequent downtime that causes delays in administrative processes and hinders the ability of the employees to serve the public efficiently. One major concern observed by the researchers is the physical security of network hardware, such as

routers and servers. These critical components are not adequately secured, making them vulnerable to tampering, theft, or unauthorized access. Without proper physical security measures, the risk of physical breaches can lead to severe disruptions in network operations and compromise the integrity and confidentiality of sensitive data.

Addressing these problems is crucial to ensure the smooth and secure operations of City Hall. This assessment is essential in identifying vulnerabilities in the current setup including the lack of physical security for network hardware, and provide a guide for improvements.

According to the study, physical assets within a critical infrastructure system is very crucial for enhanced security and systems dependent to it. This is particularly important for communication systems. This paper presents a multilayer complex network framework that takes into account the heterogeneity of the redundant infrastructure. (Herrera et. al, 2023) However, even this study contributes a lot in managing network infrastructure existing models do not sufficiently incorporate the concept of redundancy, which is crucial for network resilience and reliability. This study often utilizes a single-layer network approach, which fails to capture the complexity and heterogeneity of real-world communication infrastructures. To fill those limitations this study will implement complex network to model physical and logical layers of the network.

Here, this study intends to conduct an extensive assessment of the current network infrastructure of City Hall and propose an enhanced network design, improve network performance with a particular emphasis on identifying any loopholes that may expose the institution to cyber-attacks, operational inefficiencies, or both. The digital era, defined by the rapid rate of technological advancement and the evolving sophistication of cyber threats necessitates that public institutions such as City Hall not only stay current with these changes but also safeguard against potential vulnerabilities within their network system and aim to be a model of the first smart city here in Isabela.

Scope and Limitation

This study is primarily focused on conducting a comprehensive assessment of the current network infrastructure at City Hall at Cauayan Isabela covering 17 departments. To achieve this, a custom assessment tool was developed to evaluate the existing network infrastructure. This tool aims to identify vulnerabilities, insufficiencies, and areas for improvement in network security and performance. The study included evaluating hardware such as routers, switches, servers, and cabling, as well as reviewing software including operating systems, network management tools, and security applications. Based on the findings, a new LAN design was developed to address the identified issues and to enhance the overall network security and efficiency. However, the implementation of security solutions and the operational testing of the new design are not included in this study. The accuracy of the assessment is dependent on the availability and accuracy of existing network documentation and data, and the study is constrained by current technological capabilities and resources available at Cauayan City Hall, as well as external factors like vendor support, technological advancements, and regulatory requirements.

REVIEW OF RELATED LITERATURE AND STUDIES

Design and Simulation of Local Area Network Using Cisco Packet Tracer

Simulation tools offer a way to predict the impact of a hardware upgrade, a change in topology. So, in this paper, a LAN network is designed using Cisco Packet Tracer. This study provides an insight into various concept such as topology design and simulation.

A range of studies have explored various aspects of local area network (LAN) design and simulation using Cisco Packet Tracer. G.K. (2020) focuses on performance evaluation and network segmentation, particularly examining the implementation of VLAN technology. The study by G.K. also delves into the configuration of both wired and wireless LANs, emphasizing the setup of DHCP, HTTP, and HTTPS protocols, alongside Ethernet and Wi-Fi technologies.

Building upon these concepts. Hossain (2019) finally provides a practical application by detailing the simulation and design of a university area network scenario using Cisco Packet Tracer, contributes to this body of work by giving an insight on how to properly use Cisco Packet Tracer and how crucial simulation process in building a well-designed network infrastructure (Thu, 2020).

Assessment of Network Infrastructure

According to the study, the maintenance of system flow is critical for effective network operation. Any disruption to network facilities, whether affecting arc or nodes, poses a risk of service loss, potentially leaving users without access to crucial resources. This study has proven that assessment of network infrastructure is an important way in identifying vulnerabilities in disrupting efficient flow in network (Matisziw et al., 2019).

According to the study, critical infrastructure (Cis) provides essential services to the society it highlights the need for better management of networks interactions and independencies. Interdependencies cause cascading failures and, creates negative

impact due to these failures. This study developed an integrated resilience assessment framework to identify and map interdependency-induced vulnerabilities in critical infrastructure networks (Hajializadeh, 2020).

The study emphasizes that critical infrastructure (CIs) provides essential services to society and highlights the need for better management of network interactions and interdependencies. Interdependencies can cause cascading failures, creating significant negative impacts. This study developed an integrated resilience assessment framework to identify and map interdependency-induced vulnerabilities in critical infrastructure networks.

Community Networks

According to the study, community detection is a fundamental problem in social network analysis consisting, roughly speaking, in unsupervised dividing social actors (modeled as nodes in a social graph) with certain social connections (modeled as edges in the social graph) into densely knitted and highly related groups with each group well separated from the others. Classical approaches for community detection usually deal only with the structure of the network and ignore features of the nodes (traditionally called node attributes), although the majority of real-world social networks provide additional actors' information such as age, gender, interests, etc. It is believed that the attributes may clarify and enrich the knowledge about the actors and give sense to the detected communities (Chunaev, 2020). The interconnection of network architecture and channels of information transmission and storage in the process of the internet communication. The concept of digital folklore as compared to traditional folk culture is explained. Genre classification of digital folklore is introduced. The mechanisms of digital folklore functioning within different patterns of modern network architecture are analyzed. The idea of the research is introduced based on the comparative study. The article argues that the internet forms a special communicative environment that gives rise to innovative cultural and linguistic phenomena. It reflects users' thoughts and ideas, expressed in the form of a text, synthesized with graphics, sound, and animation (Melnikova et al., 2020).

diminishes network latency and enhances network throughput in contrast to conventional data center network designs (Yang et al., 2020).

Network infrastructure devices, which facilitate data movement and communication, are vital components of modern networks. In wireless networks, the distance between stations and access points can impact Quality of Service (QoS) measurements, particularly concerning data distribution delays. Ghozali et al. (2020) demonstrated that in scenarios where wireless sensors transmit data (such as pH data acquisition) from node stations to web services, delays in data transmission can significantly affect measurement accuracy and the presentation of data on cloud servers.

Current access infrastructures are characterized by heterogeneity, low latency, high throughput, and high computational capability, enabling massive concurrent connections and various services. Unfortunately, this design does not pay significant attention to mobile services in underserved areas. In this context, the use of aerial radio access networks (ARANs) is a promising strategy to complement existing terrestrial communication systems. Involving airborne components such as unmanned aerial vehicles, drones, and satellites, ARANs can quickly establish a flexible access infrastructure on demand. ARANs are expected to support the development of seamless mobile communication systems toward a comprehensive sixth generation (6G) global access infrastructure. Dao et al., (2021) mentioned that the development of digital technologies and the transformation of the Internet into a "communication medium" lead to the formation of a network society with the large-scale development of network culture and the invasion of network business and network forms of education. Replacement of the face-to-face contact by the network communication, destruction of personal space, openness of personal life, its "inclusion in the network", simultaneous possibility of anonymity, protection and irresponsibility of users become a reality of modern life. Network systems are becoming the basic infrastructure of modern society. Zheleznyak (2021) stressed that network infrastructure vulnerabilities are the establishment for most specialized security issues and hacks in our data frameworks. These lower-level vulnerabilities affect all around that truly matters everything running on our network. That is the reason it needs to test for them and discard them at whatever point possible. The spotlight for ethical hacking tests on the network infrastructure should be to find deficiencies that others can discover in our network so we can gauge our network's element of presentation. Networking infrastructure in a company which involves server, firewall, routers, switches, LAN cards, wireless routers, cables. With the headway in computing networking and technology, the world is ending up increasingly associated (Basu, 2020).

Several studies have contributed significantly to the realm of network design. Naga et al., (2021) study focused on mathematical optimization in network design, introducing a new formulation for the problem and presenting an efficient algorithm for enumerating feasible paths to meet connectivity, capacity, and service requirements. Their proposed approach demonstrates effectiveness compared to the current state-of-the-art through extensive computational experiments.

Wang et al., (2022) stated that designing a high-efficiency and high-quality expressive network architecture has always been the most important research topic in the field of deep learning. Most of today's network design strategies focus on how to

integrate features extracted from different layers, and how to design computing units to effectively extract these features, thereby enhancing the expressiveness of the network. This paper proposes a new network design strategy, i.e., to design the network architecture based on gradient path analysis. Most of today's mainstream network design strategies are based on feed forward path, that is, the network architecture is designed based on the data path.

The study discusses design and management of network infrastructures extend beyond mere connectivity provision and they must guarantee reliability while stick to established security measures and standards in the field of information and communications technology (ICT). This study aims to underscore the significance of managing network infrastructure, which serves as the vital communication resolve in any organization. Effective management of the resources utilized in implementing infrastructure is essential to fulfill its purpose providing a high-performing IT environment conducive to secure and uninterrupted communication among the organization's stakeholders. This ensures satisfaction and protection for all users connected to the network. In summary, a robust IT infrastructure is crucial for ensuring reliability in information transmission and security within an organization's internal operations. Irrespective of the organization's nature, administrators or managers must prioritize investment in building a standardized infrastructure characterized by scalability, credibility, and cost-effectiveness (Mudzramer A Hayudini, 2022).

The study emphasizes the criticality of well-designed network infrastructure for highs-peed data centers, which are crucial amidst escalating demands for data processing and storage. The authors contend that conventional data center network architectures lack the capacity to manage the immense data traffic generated by modern applications. The study advocates for innovative approaches to network infrastructure design to effectively address these escalating demands (Nandakumar et al., 2021).

The study about network infrastructure design and traffic engineering for 5G mobile networks, heralded as the next generation in mobile technology. The study delves into the demands and obstacles in crafting a network infrastructure to sustain 5G mobile networks. It provides an outline of diverse network architectures and protocols tailored for 5G networks. Additionally, the research offers a simulation-based assessment of proposed solutions for network infrastructure design and traffic engineering (Chen et al., 2020).

This study conducts a comprehensive review of existing network infrastructure designs for healthcare applications. Emphasizing the criticality of secure, reliable, and high-performance network infrastructure in healthcare, the study delineates the challenges inherent in such design, including data privacy, security, high availability, and low latency requirements. The authors offer recommendations aimed at crafting a network infrastructure capable of accommodating the burgeoning demand for healthcare applications while upholding stringent levels of security and reliability. These insights can aid healthcare organizations in refining their network infrastructure design and augmenting their healthcare services (El-Far et al., 2021).

This study has shown that a typical network system can be built for less money. Even though we built the network with the least expensive equipment possible, its security has shown to be of the highest caliber. Every network needs numerous servers to function. Due to the expense, the researchers did not use all the servers for this study, but they did use key crucial servers like DHCP. These servers support the network's efficient operation of its functions. This study demonstrates that despite a number of obstacles brought on by budgetary limitations, we ultimately succeeded in achieving our goal by developing a network for university development at the lowest possible cost (Chetan Gaurkar, Kiran Thul & Prof. P. Jaipurkar (2023).

Synthesis

The study analyzing the current network infrastructure design within smart cities, and it offers insights into crafting a resilient and secure network infrastructure tailored to such urban environments. The study delineates key challenges associated with designing a network infrastructure for smart cities, including scalability, security measures, mobility support, and reliability. Moreover, recommendations are provided for harnessing technologies such as Software-Defined Networking (SDN), Network Function Virtualization (NFV), and edge computing to elevate network performance and fortify security measures (Nanda and Sharma (2021).

The study highlights that due to the advancement in infrastructure and rapid increment, after few years 5G will not be enough to fulfill the requirements. The study identifies the key techniques for 6G in this study it suggests the role of these techniques for future wireless communication enhancement is discussed (Singh et al., 2021).

According to the study, it has shown a growing attack against cyber-physical systems in recent years that raise a concern for cybersecurity of industrial control system (ICSs) since network systems are becoming the basic infrastructure of modern society Zheleznyak (2021). Network infrastructure must provide a secondary line of defense for cyber-attack detection (Dias et al., 2021).

LAN Security

Securing a local area network (LAN) infrastructure has become crucial due to the increasing issue in cyber-attacks.

This study proposes a Software Defines Networking (SDN) framework for LANs. The aim of the study is to optimize network management, improve performance, enhance security, and achieve cost effectiveness in LAN environments (Udo, Edward et al., 2020).

This study proposes a TorVPN access point as a solution for bolstering security and privacy on LANs. This solution leverages the Tor network to encrypt user traffic and incorporates a virtual private network (VPN) to offer supplementary security measures. Nonetheless, the solution faced connectivity challenges attributed to the inherent characteristics of the Tor network (Osman, Mohd et al., 2021).

Synthesis

This study conducts an assessment through the current network infrastructure design within disaster management system and offer insights into creating a resilient, fault-tolerant, and secure network infrastructure designed to such critical environments. The study identifies key challenges in designing such infrastructure, focusing on aspects of availability, reliability, and security. This study provides valuable guidance for mitigating vulnerabilities and enhancing a robust of network system crucial for effective disaster management (Elkhodary et al., 2019).

This study discusses about a methodology of a defensive approach usually performed by the network administrator to implement a secure network by layering and segmentation. This study defines that using VLANs or virtual private local area networks. However, according to this study, defense in depth is usually manageable in small networks and it is not scalable to larger performing network segmentation. The findings of this study simulated corporate networking scenario utilizing PVLANs, a comparative performance analysis is conducted on defensive strategies concerning CPU and memory usage, communication delay, packet loss, and power consumption. This analysis involves executing a recognized PVLAN attack with simulated attackers positioned within the corporate network. Subsequently, two mitigation strategies are examined and contrasted, employing the traditional approach of access control lists (ACLs) and SDNs. (Alvarez et al., 2023).

Network Infrastructure Design for big Data Transmission in Smart Cities

In the rapidly evolving landscape of urban development, the emergence of smart cities represents a transformative shift towards leveraging technology to enhance the quality of life for citizens while optimizing resource management. At the heart of this paradigm shift lies the seamless transmission of vast amounts of data essential for enabling smart city functionalities.

This study highlights the emerge of smart cities aims at mitigating the challenges raised due to the continuous urbanization to solve this issues government and decision makers undertake smart city projects. This study identifies the key in enabling technology for city smartening. However, ICT yield massive volume of data known as big data. Yet, to harness valuable insights for the development of comprehensive city-level smart information services, the datasets generated across diverse urban domains must be seamlessly integrated and rigorously analyzed. This intricate process, commonly known as big data analytics or the big data value chain, lies at the core of deriving actionable intelligence from vast and disparate data sources within smart city environments (Osman, 2019).

This study requires coordination within the technological dimension as well as within the institutional dimension. It also shows how fundamental the alignment between these two dimensions is. It argues that this alignment operates along different layers characterized successively by the structure, governance and transactions that connect technologies and institutions. These issues of coordination and alignment, at the core of the book, are substantiated through in-depth case studies of networks from the energy, water and wastewater, and transportation sectors (Kunneke, 2021).

According to the study, big data allows organizations to process huge and complex data and share through network. According to the stud, organization network requires and secured and efficient platform. In this study, network security platforms have to deal with vast and complex information to predict and prevent potential attacks in real-time (Gahi et al,2020).

CHAPTER II

TECHNICAL BACKGROUND

This chapter presents key concepts and considerations involved in network infrastructure design. It includes topics such as Conceptual Framework, System Architecture, Physical Network Design, Computer Network Planning, Network Topology and Logical Network Design, providing a comprehensive understanding of network infrastructure planning and implementation.

Conceptual Framework

This framework serves as the foundational concept in achieving the set of objectives highlight in this research. This is used to identification of concept and organizing ideas. Conceptual frameworks represent something actual in an easy-to-remember and apply format.

Research Paradigm

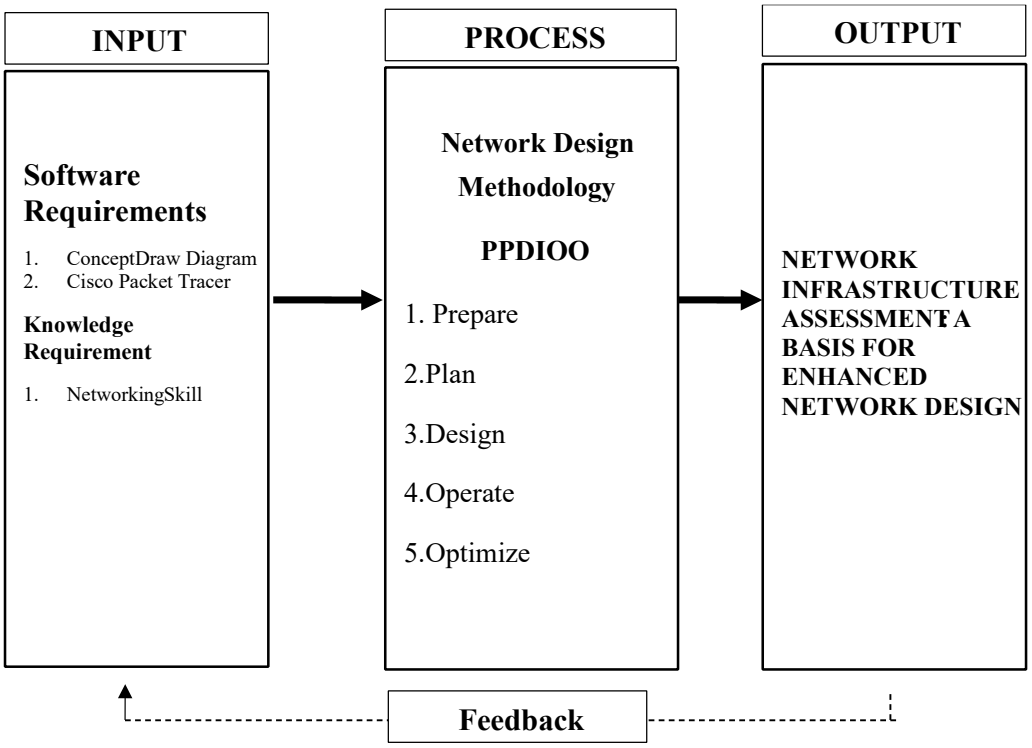


Figure 2.1 Research Paradigm of Network Infrastructure Design in Cauayan City Hall

This diagram presents the processes that illustrate the input, process, and output involved in identifying the objectives and capabilities of Network Infrastructure Design in City Hall. These processes include the input, which represents the requirements and approaches needed to fulfill the objectives, such as software requirements which include the Cisco Packet Tracer. Last but not the least, the knowledge in networking by the researchers followed by the process stage follows the PPDOO Methodology that involves preparation, planning, designing, operating, and optimizing. Lastly, the output stage delivers the results and function of the input, leading in a creative Network Infrastructure Design in City Hall.

Network Architecture

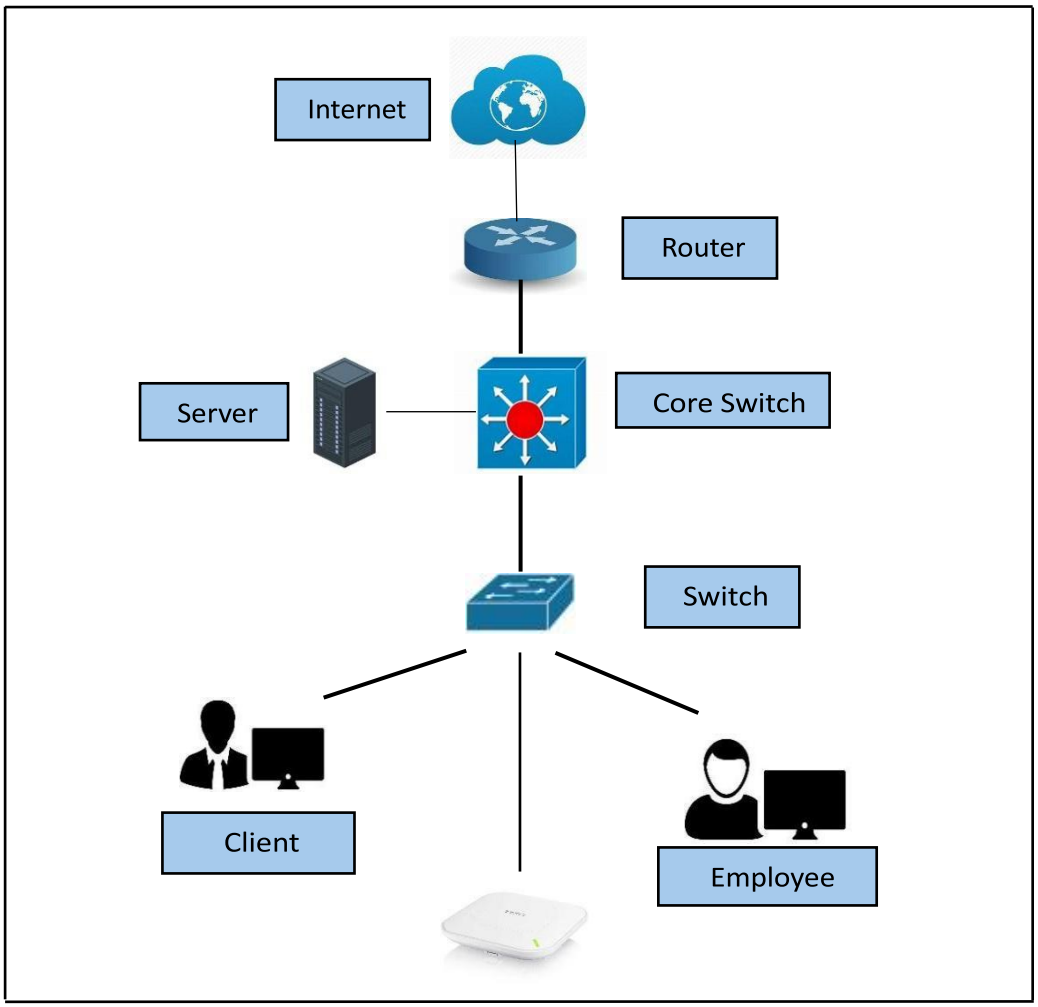


Figure 2.2 Network Architecture of Network Infrastructure Design in Cauayan City Hall

An architectural description is a description and representation of a system that is arranged in a way that allows for reasoning about the system's structures and actions.

Program Requirements

The table below provided a list of the essential requirements. This section recommended the suggested materials to be used in miniature and software to be utilized.

A. Software Requirements

Table 2.1 Software Requirements of Network Infrastructure Design in Cauayan City Hall

Software	Description
Cisco P Tracer 	• **Device Emulation:** This Software imitates the functionality of different cisco networking devices, such as routers, switches, and firewalls • **Packet Visualization:** This feature enables users to see and examine the movement of packets across the network aiding in analyzing and understanding data transmission. • **System Specification:** Specifications regarding operating systems

ConceptDraw DIAGRAM **ConceptDraw**	• **Real-time Visualization:** Offers live representation of network operations, assisting users in understanding configurations and troubleshoot issues. • **Visualization Tools Suite:** Concept Draw offers a complete package of diagramming tools for creating varieties of diagrams, charts, and visual representations. • **Flexible Diagrams:** Concept Draw enables users to create a wide range of diagrams, such as flowcharts, organizational charts, network diagram, floor plans, and more. • **Customization:** This software enables users to customize the appearance of diagrams by adding details, annotations, and style to meet specific requirements.

Network Topology

A tree topology is an ideal choice for the network design of Cauayan City Hall due to its hierarchal structure and scalability. In a tree topology, network devices are organized into multiple levels, resembling to the structure of network layout. At the core of the network sits a central switch or router, representing the trunk, from which each of the department in Cauayan City Hall extend to connect to intermediate switches or routers on each floor or department, and finally, to end devices such as computer and printers.

Virtual Local Area Network

To enhance security, this proposed network design prioritizes the implementation of Port Security measures, which restrict the access point to switch ports only to authorized devices with recognized MAC addresses. This effectively mitigates the risk of unauthorized network entry.

In addition to with Port Security, VLANs are used to logically segment network into distinct groups, establishing clear boundaries for different device categories and reducing the likelihood of unauthorized access. By serving as protective layer, VLANs effectively regulate communication within their respective segments, acting as overall network defense.

VLAN ID

Table 2.2 VLAN ID

Devices	VLAN ID
Ground Floor	**10**
Second Floor	**20**
Third Floor	**30**
Access Point	**40**

Table 2.3 IP Address Scheme

DEPARTMENTS	IP ADDRESS	SUBNET MASK
City Treasurer Office	172.16.10.3/28	255.255.0.0
City Budget Office	172.16.10.29/34	255.255.0.0
City Budget Office Staffs	172.16.10.35/41	255.255.0.0
One Stop Office	172.16.10.42/47	255.255.0.0
BAC Office	172.16.10.48/54	255.255.0.0
BPLO	172.16.10.55/80	255.255.0.0
City Tourism Office	172.16.10.81/93	255.255.0.0

City Planning & Development Office	172.16.20.3/17	255.255.0.0
City Engineers Office	172.16.20.18/21	255.255.0.0
City Architect Office	172.16.20.22/30	255.255.0.0
Commission on Audit Office	172.16.20.31/39	255.255.0.0
City Human Resource MNGT.OFFICE	172.16.20.40/46	255.255.0.0
City General Services Office	172.16.20.47/53	255.255.0.0
City Accountant Office	172.16.20.54/60	255.255.0.0
City Accountant Staff	172.16.20.61/83	255.255.0.0
Mayor's Office	172.16.30.3/21	255.255.0.0
City Information and Communication Office	172.16.30.22/40	255.255.0.0

CHAPTER III
METHODOLOGY

The data collection methods applied for the study are outlined in this chapter covering preparation, planning, design, implementation, operation, and optimization phases.

Network Design Methodology

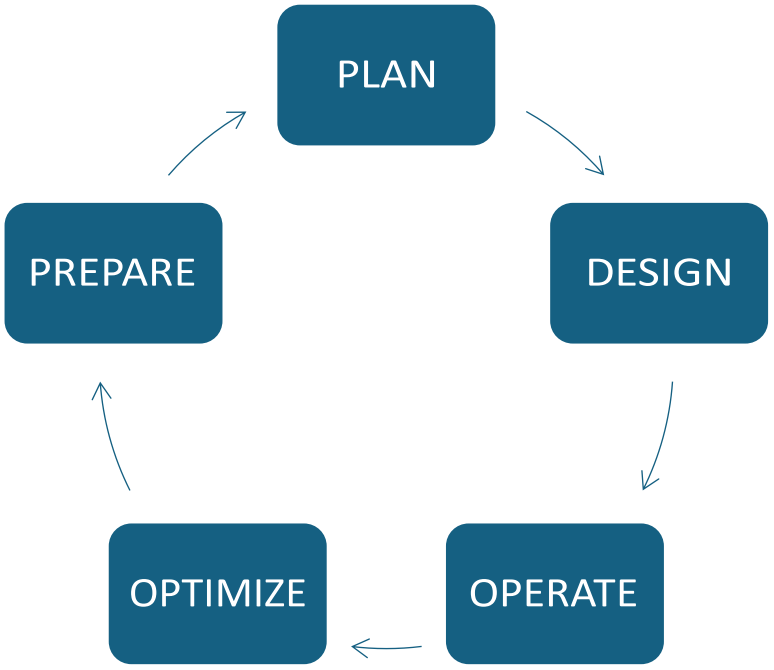


Figure 3.1 Network Design of Network Infrastructure Design in Cauayan City Hall

According to Yuliana and Mogi (2020), in building a network design, a concept and a method is crucial in designing it. The project incorporates the PPDOO approach, which is divided into several stages: Prepare, Plan, Design, Operate and Optimize. Some requirements are needed when designing this network design, such as Access Point-PT, Switch, PC-PT, Server-PT, Router PT, Switch-through Copper Cable, and Cross over Copper Cable. Using the PPDOO approach has the potential to enhance network performance.

PHASE 1: PREPARE

In this phase, the researchers gathered requirements including knowing the exact location of where the network devices will be placed. Also, they determined any loopholes and insufficiencies in their current network setup.

PHASE 2: PLAN

This phase involves the process of evaluating the sites where the network is intended to be deployed, as well as any pre-existing networks. This includes conducting a thorough gap analysis to determine whether the current system infrastructure, sites, and operational environment can accommodate the proposed system.

PHASE 3: DESIGN

This phase involves the researchers' gathering of requirements, which led the network design. The design is according to the determined initial requirements, utilizing any additional data gathered during network analysis and network audit, particularly when upgrading an existing network, as well as through discussions with department head and network users and finally, the utilization of cisco packet tracer to design the network and simulate in computing environment.

PHASE 4: OPERATE

This phase involves sustaining the health of the network through day-to-day operations, which includes ensuring high availability and minimizing expenses, and testing the proposed network design by using Cisco Packet Tracer for simulation.

PHASE 5: OPTIMIZE

This phase focuses specifically on enhancing system performance, provides a structured framework for managing the entire lifecycle of the network design, including optimization.

Respondents of the Study

To determine the required number of respondents, the researchers used a reliable method.

Table 3.1 Frequency Distribution of Respondents

Respondent	Frequency	Percentage
IT Experts	5	33%
Network Administrator	10	67%
Total	**15**	**100%**

Sampling Technique

This Study used stratified random sampling techniques to ensure an accurate and unbiased presentation of the population being studied.

$n_i = f_i \times N_i$

Where:

n_i = Sample size for stratum i.

f_i = Sampling fraction for stratum i($f_i = n_i / N_i$).

N_i = Population size of stratum i.

Statistical Treatment

The Likert Scale was used to interpret the items in the questionnaire and obtain the overall evaluation result of the proposed project.

Statistical Interpretation of Data

Table 3.2 Statistical Interpretation of Data

NUMERICAL SCALE	RANGE	INTERPRETATION
5	4.21 – 5.00	Strongly Agree
4	3.41 – 4.20	Agree
3	2.61 -3.40	Neutral
2	1.81 – 2.60	Disagree
1	1.00 – 1.80	Strongly Disagree

The data that will be gathered will be analyzed to determine the weighted mean with the following formula:

$$Weighted\ Mean = \frac{\Sigma(\chi \cdot \omega)}{\Sigma\omega}$$

Where:

$\Sigma(\chi \cdot \omega)$ = is the sum of the products formed by multiplying each number by its assigned weight.

$\Sigma\omega$ = is the sum of all weights.

CHAPTER IV
RESULTS AND DISCUSSION

This chapter presents the result of the findings of the study, providing a detailed analysis and interpretation of the collected data. The result section highlights the key discoveries from the research, organized clearly and logically. Following this, the discussion critically evaluates these findings in relation to research question and relevant literature.

TABLE 4.1 ***Result of Assessment in Terms of Hardware and Software***

COMPONENTS	QUANTITY	Specifications
Printer	12	Epson EcoTank L3210 A4
ROUTER	10	**RAM:** 512MB to several GBs **CPU:** Multi-core processor **Ports:** 10/100/1000MBPS
SWITCH	15	Tenda Switch 5-10 port Rg-Es116g 25 port Rg-Es116g 16 port
COMPUTER/LAPTOP	193	Hp Desktop PC Intel Core i3 1TB HDD 8GB Lenovo Factory Intel Core i7 16GB + 512GB SSD Lenovo Quad Core i5 3.1GHz, 8GB RAM 500GB

Table 10 highlights the current hardware used at City Hall, but several issues hinder its efficiency. The limited number of printers may not suffice for 193 computers, especially in high-demand departments, leading to delays and overuse. The router, with only 512MB of RAM, struggles to handle peak traffic volumes, and the absence of a centralized server necessitates the costly use of 10 separate routers. Switches with only 5–10 ports restrict scalability and complicate network expansion, while varying computer specifications and the use of slower HDDs in some systems create performance gaps and inefficiencies. To address these issues, it is recommended to add more printers or centralized high-capacity models, upgrade to high-performance routers, and introduce a central server to reduce router dependence. Replacing low-port switches with higher-port models and standardizing switch brands will simplify management and support expansion. Additionally, upgrading computers to SSDs and standardizing specifications across departments may improve workflow efficiency. Implementing managed switches and layer 3 devices will streamline traffic flow, and regular hardware audits will ensure long-term reliability and performance.

Table 4.2 Proposed Hardware

HARDWARE	QUANTITY
Router	4
Managed Switch TP-Link TL-SG108PE	1
Switch Cisco Catalyst 2950 24-PORT 10/100 Fe	14
Access point/ WIFI Ubiquiti Networks UniFi AP LR WiFi PoE Wireless Access Point	14
UTP Cable	2,000m
RJ45 Cat6 100 pcs per box	3
Patch Outlet/ RJ45 double socket	13
Server TERRAMASTER T9-450 9Bay NAS Storage - High Speed Network Attached Storage with Atom C3558R Quad-core CPU, 8GB DDR4 Memory, Dual SFP+ 10GbE Interfaces, Dual 2.5GbE Ports, NAS Server (Diskless)	1

The proposed network design incorporates one centralized route: one managed switch, and 14 access switches, ensuring comprehensive coverage and efficient data distribution. To accommodate, wireless devices such as smartphones and laptops are strategically placed in accessible points which provides reliable Wi-Fi connectivity. The inclusion of a centralized server will streamline network management, enhance data storage, and facilitate resource sharing across departments. This setup ensures improved scalability, optimized network performance, and seamless integration of wired and wireless devices, addressing current and future connectivity needs efficiently.

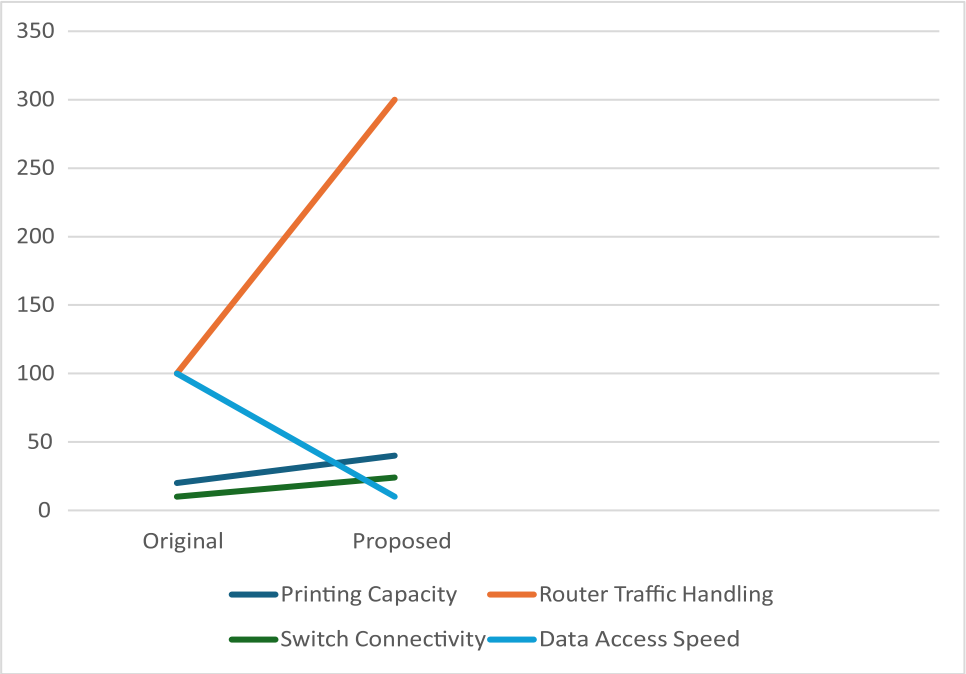


Figure 4.1 Comparison of Current vs. Proposed System Performance

In the original setup, printers were inadequate for high-demand departments, leading to delays. This proposal introduces centralized, high-capacity network printers, reducing queue times by 50%. Similarly, the current routers with 512MB RAM struggle

with peak traffic, while the proposed upgrade to 2GB routers ensures smooth operation even during heavy usage, improving traffic handling by 3x. By replacing limited-port switches with higher-capacity models and standardizing hardware, this proposal not only resolves current connectivity bottlenecks but also simplifies future expansions and maintenance. These enhancements demonstrate clear, measurable improvements over the existing configuration.

Table 4.3 Software Inventory at Cauayan City Hall

Software	Descriptions
Operating Systems	• Windows 10 • Windows 11
Security Software	MS firewall • Windows Firewall with advanced security
Work applications	Microsoft Office 365 Filmorago CorelDRAW Google Chrome

The table above shows the software utilized in City Hall which includes a range of tools designed to support various administrative and operational tasks. The operating systems in use are Windows 10 and Windows 11, providing a stable and modern platform for day-to-day activities, though the presence of both versions may require additional management for compatibility and updates. Security is addressed through MS Firewall and Windows Firewall with Advanced Security, ensuring basic protection for the network and systems.

For productivity and work applications, the City Hall employs Microsoft Office 365 for documentation, data analysis, and presentations, along with FilmoraGo for video editing and CorelDRAW for graphic design, catering to creative and multimedia requirements. Google Chrome serves as the primary web browser, facilitating internet access and the use of web-based applications.

PHYSICAL LAYOUT OF THE CITY HALL

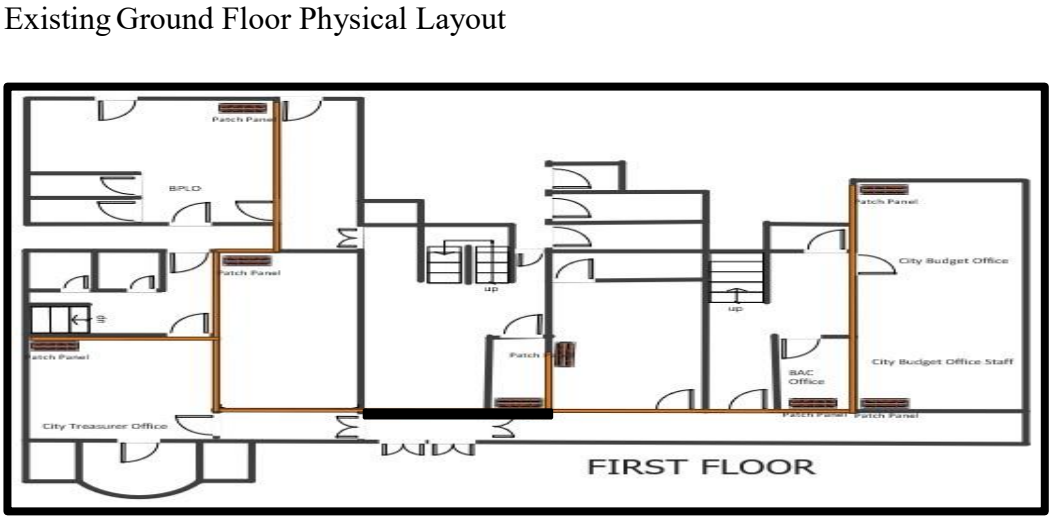


Figure 4.2 Physical Layout of the City Hall (Ground Floor)

The figure shows the physical layout of the Cauayan City Hall ground floor

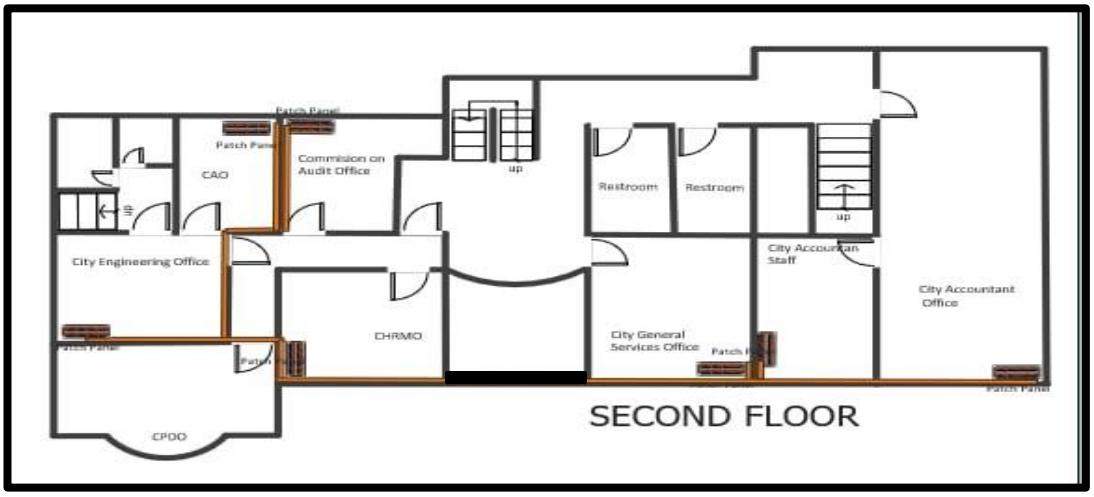


Figure 4.3 Physical Layout of the City Hall (Second Floor)

The figure shows the physical layout of the Cauayan City Hall second floor.

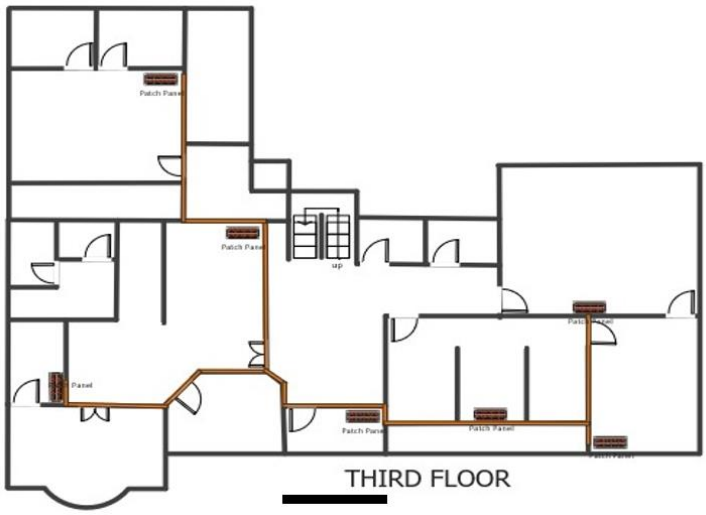


Figure 4.4 Physical Layout of the City Hall (Third Floor)

The physical layout of City Hall showcases an impressive level of design and implementation, reflecting adherence to industry standards and best practices. However, the cabling and devices are limited to specific departments, preventing seamless communication across the organization as they are not on the same network. This segmentation hinders collaboration and efficiency, highlighting the need for an enhanced network infrastructure that integrates all departments into a unified system. The strategic placement of devices, neat cable management, effective power distribution, and robust cooling and physical security systems highlight a commitment to operational efficiency and reliability. However, while the physical setup is excellent, there is a noticeable gap in the area of personnel expertise. The absence of trained IT professionals poses a significant risk, as a skilled workforce is critical for maintaining, optimizing, and troubleshooting such a complex infrastructure. Without qualified personnel, even the most well-designed network can face challenges during emergencies, updates, or technological upgrades.

To address this, it is highly recommended that the organization invest in hiring certified network professionals or provide training for existing staff. Certifications such as Cisco Certified Network Associate (CCNA) or CompTIA Network+ can ensure that personnel have the expertise to monitor, maintain, and enhance the system effectively. Additionally, the company should focus on future-proofing its infrastructure. This can include planning for scalability by reserving space for new devices, transitioning to advanced technologies like WiFi 6 or fiber-optic cabling to meet growing demands.

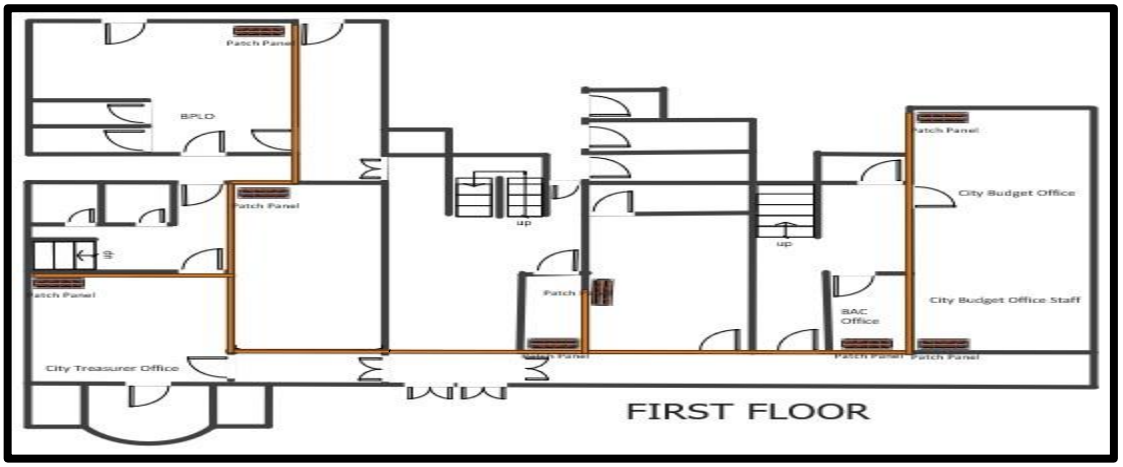


Figure 4.5 Proposed Ground Floor Physical Layout

The figure shows the proposed physical layout of the Cauayan City Hall ground floor, ensuring that all departments are connected to each other for seamless communication and data monitoring.

Proposed Second Floor Physical Layout

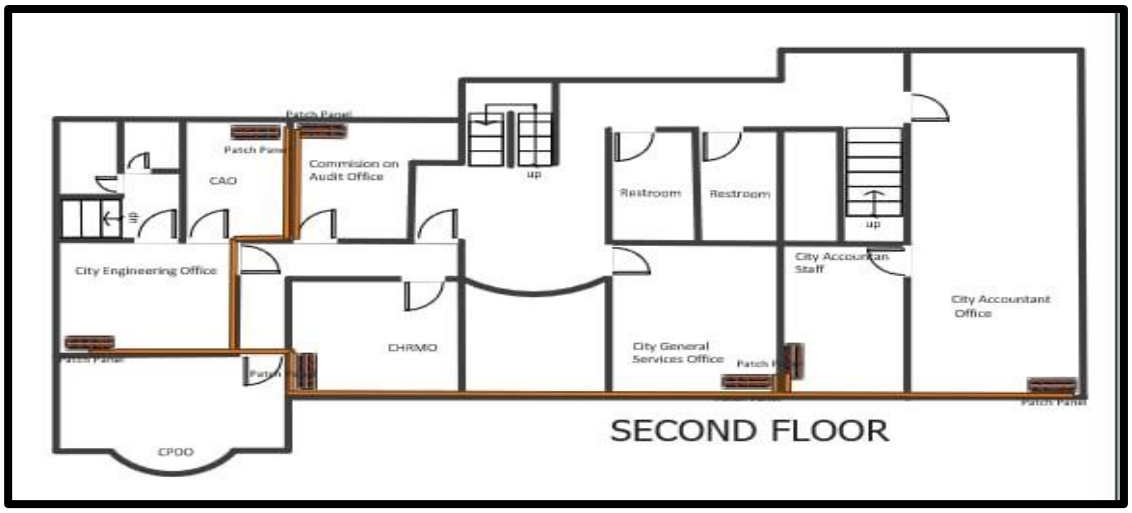


Figure 4.6 Proposed Second Floor Physical Layout

The figure shows the proposed physical layout of the Cauayan City Hall second floor. Ensuring department are connected to each other for seamless communication and data monitoring.

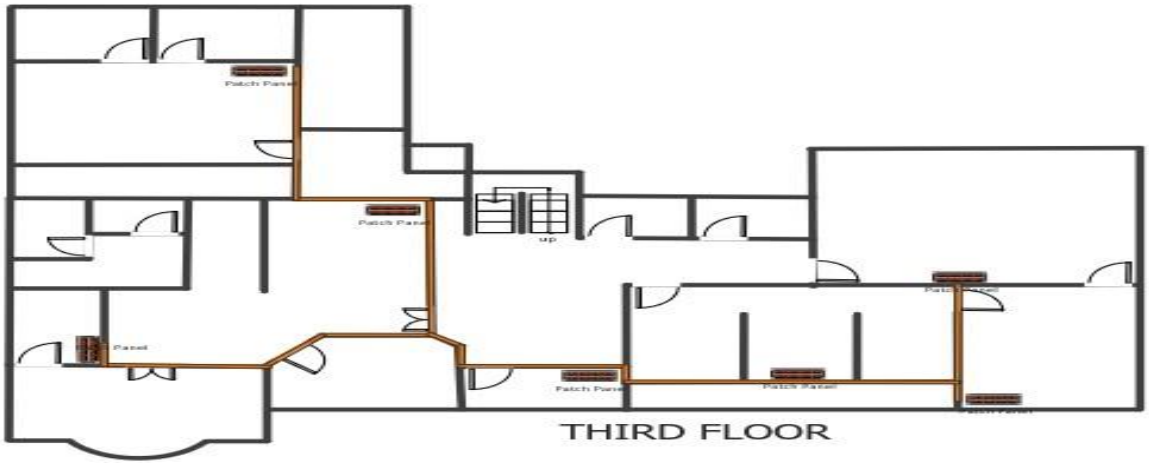


Figure 4.7 Proposed Third Floor Physical Layout

The figure illustrates the proposed physical layout of the third floor of Cauayan City Hall, designed to ensure that all departments are interconnected. This layout promotes seamless communication and efficient data monitoring by unifying the network infrastructure across all departments.

Network Map

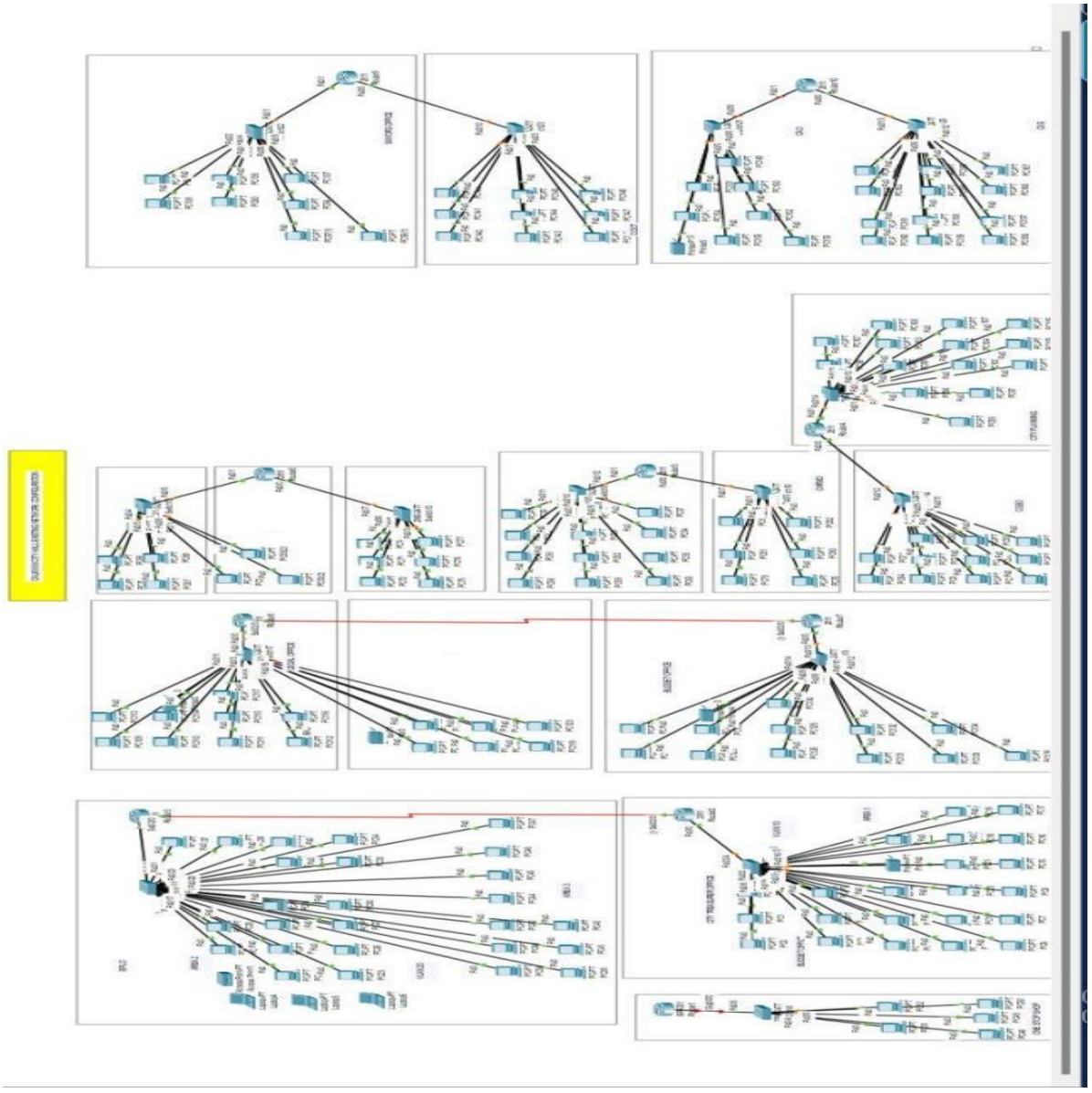


Figure 4.8 Existing Network Infrastructure Design using Cisco Packet Tracer

The figure shows the current network infrastructure design using cisco packet tracer. Based on the illustration at the first floor, 2 routers is connected to each other and placed at two different department, while a single router is placed at the OSS and is not connected to any departments. At the second floor, 3 routers are placed and does not connect to any of the routers. Additionally, on the third floor, 2 routers is also placed to facilitate mayor's office and cicto. This design leads to significant inefficiencies, including higher monthly internet subscription costs due to multiple routers, limited interconnectivity among departments, and increased complexity in managing the network. Additionally, the City Hall currently utilizes a star topology for its network. While a star topology is simple and easy to implement, it has significant limitations that make it less ideal for a complex environment like Cauayan City Hall in a star topology. All devices are directly connected to a central hub or switch. This creates a single point of failure. If the central hub or switch experiences an issue, the entire network is disrupted. Additionally, as the network grows with more devices and departments, a star topology can become inefficient and challenging to scale. The central hub may experience bottlenecks, leading to reduced performance across the network.

A tree topology is a more suitable alternative due to its hierarchical structure and scalability. In this design, a central router or switch serves as the "trunk" of the network, connecting to intermediate switches or routers that branch out to different departments or floors. This layered approach distributes the network load more effectively and reduces the risk of a single point of failure. Furthermore, it simplifies network expansion and management, making it easier to isolate and troubleshoot issues without disrupting the entire system.

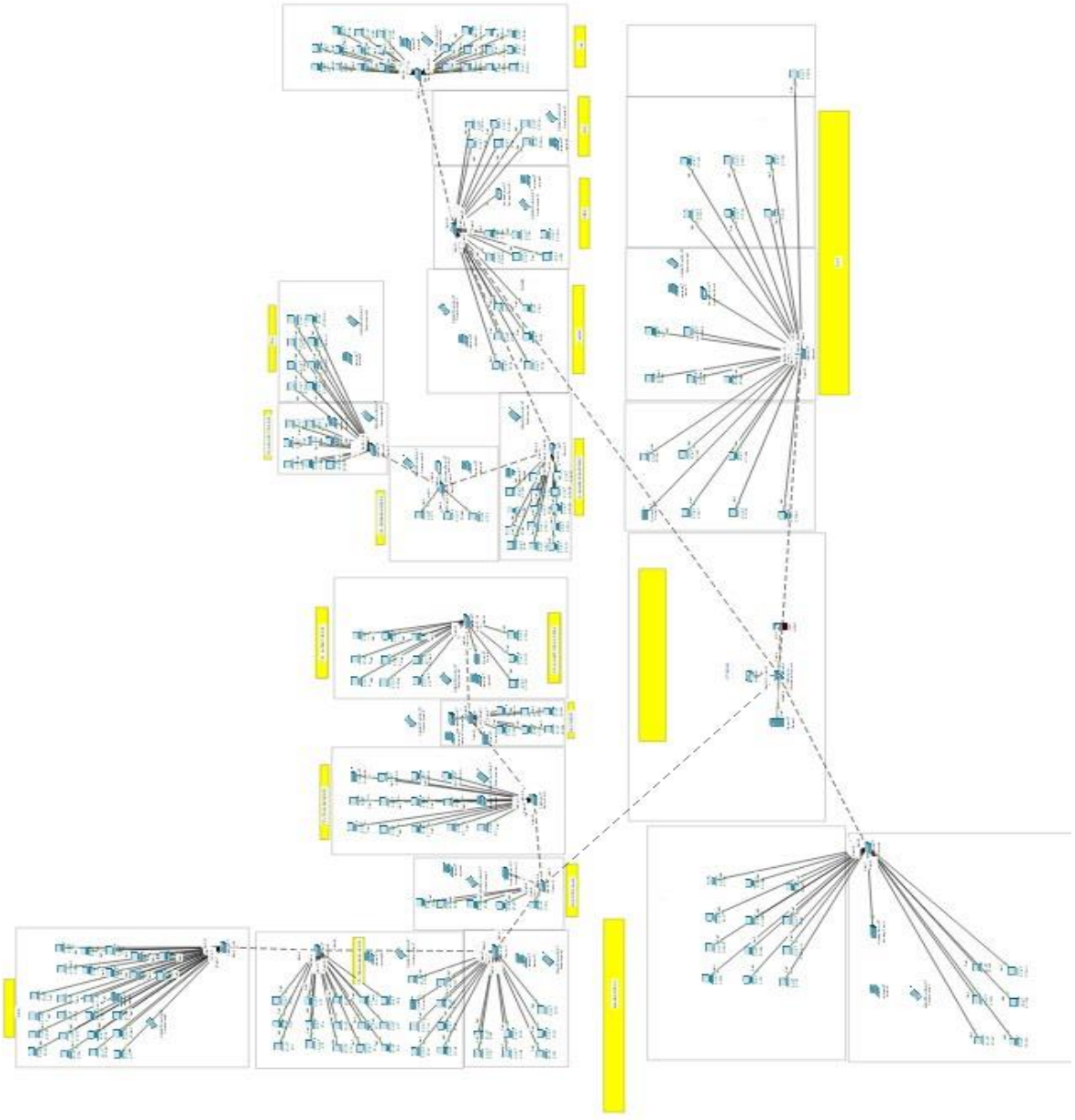


Figure 4.9 Existing Network Infrastructure Design using Cisco Packet Tracer

Figure 12 shows the proposed design using cisco packet tracer where researcher examine the use of tree topology instead on the original design star topology on their network map.

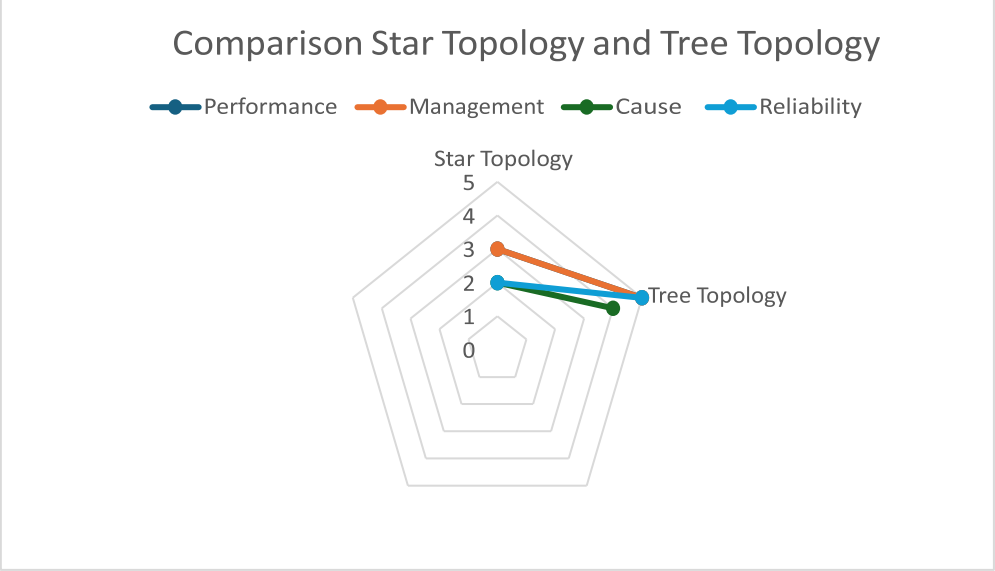


Figure 4.10 Existing Network Infrastructure Design using Cisco Packet Tracer

After the gathering of data and after comparing the findings, it clearly indicates that the tree topology offers significant advantages over the current star topology. By consolidating the network into a hierarchical structure, the tree topology reduces costs, enhances scalability, and improves overall performance. The risk of network-wide disruption is minimized, and management becomes more efficient. While the initial transition may require an investment in new equipment, the long-term savings and operational benefits outweigh the costs.

Network Speed/Performance

The current network infrastructure at City Hall, which allocates 100 Mbps per department, often experiences congestion, particularly in departments with a large number of connected devices. Additionally, excessive internet usage by some employees negatively impacts overall performance, causing slower speeds for others. To address these challenges, it is recommended to upgrade departmental bandwidth to at least 1 Gbps, supported by a fiberoptic backbone for higher data transfer rates. Implementing Quality of Service (QoS) policies can prioritize critical traffic, while network segmentation through VLANs will help isolate departmental traffic and reduce congestion. Replacing outdated hardware with Gigabit or Multi-Gigabit network devices and deploying Wi-Fi 6 access points in high-density areas will further improve performance. Additionally, setting a bandwidth limit of 10 Mbps per PC using bandwidth management techniques, such as throttling and firewall rules will ensure fair usage and prevent misuse. These measures will optimize network speed, minimize congestion, and provide reliable connectivity for all departments.

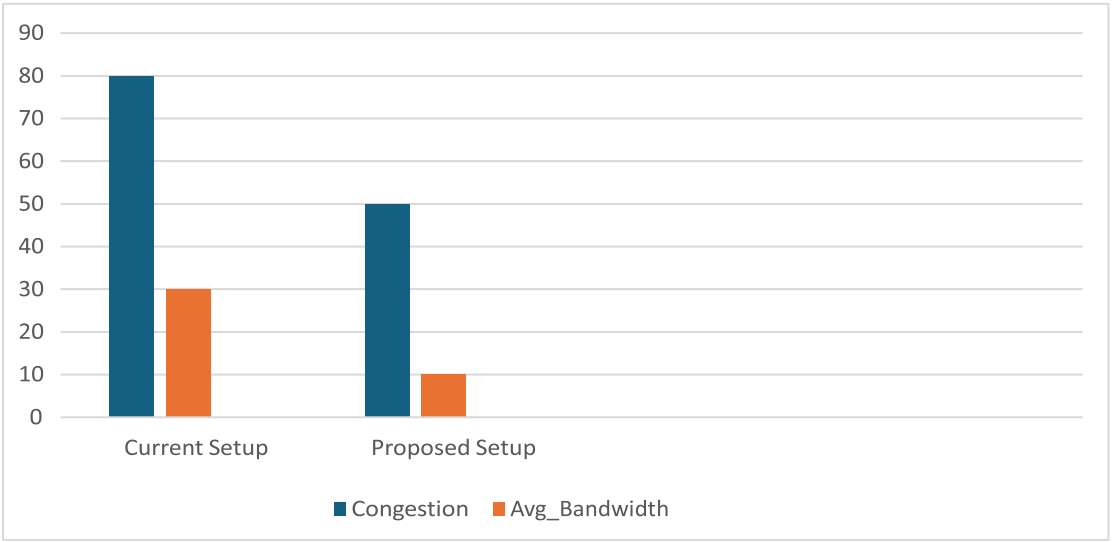


Figure 4.11 Result of Comparison between the Current Set-up and the Proposed Design

Network Infrastructure Assessment: A Basis for Enhanced Network Design

Based on the simulation, the figures clearly illustrate that the proposed network setup offers superior performance in managing congestion and maintaining average bandwidth. The enhanced configuration significantly reduces bottlenecks, ensuring a more even distribution of bandwidth across departments, especially in high-traffic areas. This improvement highlights the effectiveness of the proposed upgrades, making the network more reliable and capable of supporting the demands of modern applications and increased device usage.

Network Security and Processes

Cauayan City Hall has also been experiencing data breaches, leading to the leak of sensitive private files containing the data they collect every day. This situation raises serious concerns about the security of the information entrusted to them by the citizens. The breach has not only compromised the privacy of individuals but has also damaged the trust between the public and the city hall, potentially exposing them to legal consequences and reputational harm. The current security measures rely heavily on Access Control Lists (ACLs) to regulate network traffic. While ACLs can provide a basic level of security by allowing or denying traffic based on IP addresses and port numbers, they have significant limitations that make them insufficient for addressing modern security threats and only evaluate the headers of packets, meaning they cannot analyze the contents of data being transmitted. This makes them ineffective against sophisticated attacks, such as malware embedded in data packets.

Additionally, the absence of a firewall further compounds the problem. Without a firewall, there is no centralized mechanism to monitor and filter network traffic, leaving the entire network exposed to potential breaches. Firewalls also provide critical features like intrusion prevention, traffic logging, and advanced threat detection none of which are available with ACLs alone. Above all, Cauayan City Hall also uses unlicensed Microsoft office that may be one of the causes of breaches, unlicensed software does not receive official updates, leaving it vulnerable to exploits and cyberattacks.

Services

The researchers recommended optimizing the network infrastructure to improve the delivery of network services, ensuring both internal and operations and public services are supported efficiently. Given that the current monitoring tool is the Tenda G3, the researchers recommend enhancing its capabilities to optimize network performance and service delivery. The Tenda G3 is a useful tool, but integrating additional network monitoring software could provide more detailed insights, such as traffic analysis, real-time alerts, and performance metrics for better decision-making.

IP Addressing Structure

Table 4.4 Existing IP Address Scheme

DEPARTMENTS	IP ADDRESS	SUBNET MASK
City Treasurer Office	192.168.10.3/28	255.255.255.0
City Budget Office	192.168.10.29/34	255.255.255.0
City Budget Office Staffs	192.168.10.35/41	255.255.255.0
One Stop Office	192.168.20.42/47	255.255.255.0
BAC Office	192.168.30.42/47	255.255.255.0
BPLO	192.168.30.42/47	255.255.255.0
City Tourism Office	192.168.30.42/47	255.255.255.0
City Planning & Development Office	192.168.10.42/47	255.255.255.0
City Engineers Office	192.168.10.42/47	255.255.255.0
City Architect Office	192.168.10.42/47	255.255.255.0
Commission on Audit Office	192.168.20.42/47	255.255.255.0
City Human Resource MNGT.OFFICE	192.168.20.42/47	255.255.255.0
City General Services Office	192.168.20.42/47	255.255.255.0

City Accountant Office	192.168.30.42/47	255.255.255.0
City Accountant Staff	192.168.30.42/47	255.255.255.0
Mayor's Office	192.168.10.42/47	255.255.255.0
City Information and Communication Office	192.168.20.42/47	255.255.255.0

The existing IP addressing scheme is insufficient for interdepartmental communication, as it prevents seamless connectivity between the departments. The current configuration fails to integrate the network across all areas, creating barriers to efficient data sharing and collaboration. A revised IP addressing plan is needed to ensure proper communication between all departments.

Table 4.5 Proposed IP Address Scheme

DEPARTMENTS	IP ADDRESS	SUBNET MASK
City Treasurer Office	172.16.10.3/28	255.255.0.0
City Budget Office	172.16.10.29/34	255.255.0.0
City Budget Office Staffs	172.16.10.35/41	255.255.0.0
One Stop Office	172.16.10.42/47	255.255.0.0
BAC Office	172.16.10.48/54	255.255.0.0
BPLO	172.16.10.55/80	255.255.0.0
City Tourism Office	172.16.10.81/93	255.255.0.0
City Planning & Development Office	172.16.20.3/17	255.255.0.0
City Engineers Office	172.16.20.18/21	255.255.0.0
City Architect Office	172.16.20.22/30	255.255.0.0
Commission on Audit Office	172.16.20.31/39	255.255.0.0
City Human Resource MNGT.OFFICE	172.16.20.40/46	255.255.0.0
City General Services Office	172.16.20.47/53	255.255.0.0
City Accountant Office	172.16.20.54/60	255.255.0.0
City Accountant Staff	172.16.20.61/83	255.255.0.0
Mayor's Office	172.16.30.3/21	255.255.0.0
City Information and Communication Office	172.16.30.22/40	255.255.0.0

The table shows proposed IP addressing scheme groups the departments by sub-netting using a Class B IP address. This approach ensures a centralized network that is easier to monitor and enables seamless communication between all departments. By organizing the network in this way, it simplifies management, improves performance, and ensures that all departments can efficiently interact with each other.

The researchers used Dynamic Host Configuration Protocol (DHCP) to automate IP assignment process and to minimize the chances of IP address conflict or misconfigurations, ensuring smoother network operations, useful in the City Hall's large network. Additionally, VTP was implemented to ensure consistency across switches and simplify VLAN management in the Cauayan City Hall infrastructure. This approach streamlines network administration and improve operational efficiency. Furthermore, Quality of Service (QoS) protocols was introduced to optimize network performance, prioritize critical traffic, and ensure consistent

service delivery across the network. The researchers will also use the class b type of IP to cater all end devices and addition of end devices in the future.

Virtual Local Area Network

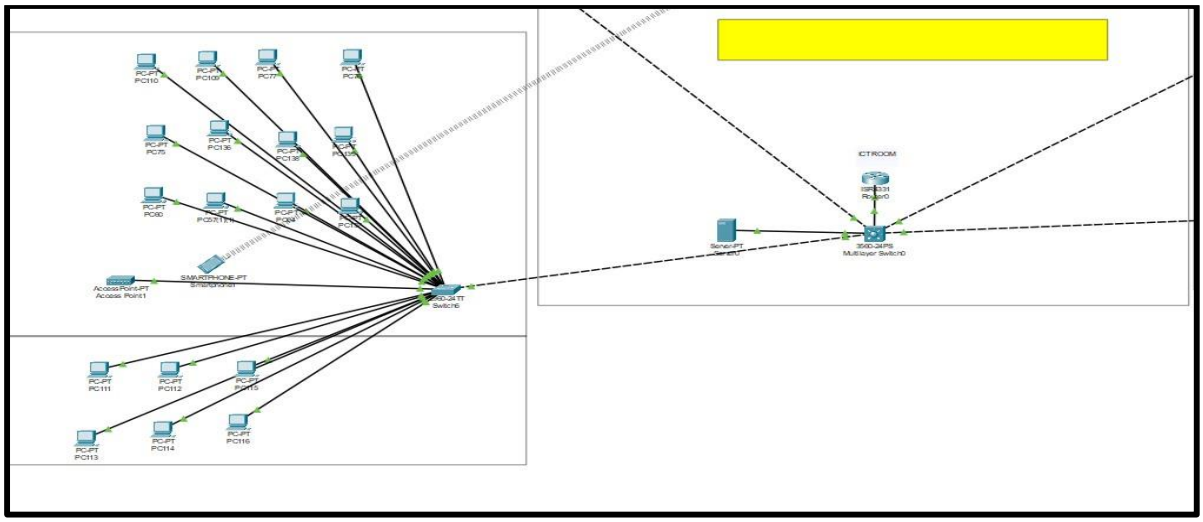


Figure 4.12 Model Design of Cauayan City Hall

This proposed network design prioritizes port security and VLANs (Virtual Local Area Networks) to ensure robust network security. VLANs allow for logical segmentation of the network into distinct groups, defining boundaries for specific device clusters and minimizing the risk of unauthorized access. By isolating traffic within each segment, VLANs act as effective barriers, controlling communication between devices.

Port security adds another layer of protection by restricting access to the network. It limits the number of devices that can connect through a given switch port, allowing only recognized devices identified by their MAC addresses. This helps prevent unauthorized access and enhances overall network security.

Devices connected in the network

Wi-Fi 6, also known as 802.11ax, was deployed with access points strategically placed throughout each building to ensure complete coverage. While it uses the same 2.4 GHz and 5 GHz bands as its predecessor, Wi-Fi 6 also offers the option to utilize the 6 GHz band for improved performance.

Patch outlets were installed in each department to support connections for devices such as printers, TVs, and other equipment. UTP (Cat6) cables were used to connect computers and devices in offices and rooms to data cabinets, ensuring reduced interference, fewer errors, and higher data transmission speeds.

For inter-building connectivity, fiber optic cables were used to link data cabinets. These cables offer faster data transmission, higher durability under tension compared to copper cables, and increased resistance to damage and breakage. Fiber optic cables are also flexible, able to bend easily, and more resistant to corrosive elements that can degrade copper cables.

Network Infrastructure Assessment: Findings and Insights from the Questionnaire.

The data collected through the evaluation of the existing network infrastructure is summarized below, as derived from the Network Infrastructure Design Questionnaire.

Table 4.6 Physical Layout

QUESTIONS	AVERAGE	DESCRIPTION
1. The designed network floor plan effectively supports the Cauayan City Hall building connectivity needs.	4.33	STRONGLY AGREE
2. The designed network floor plan adequately addresses the Cauayan City Hall building scalability requirements.	4.33	STRONGLY AGREE

3. The design of the network floor plan makes networking connections and equipment easier to access.	4.4	STRONGLY AGREE
4. The network floor plan design allows for easy scalability to accommodate future growth and changes.	4.33	STRONGLY AGREE
MEAN	**4.35**	**STRONGLY AGREE**

In Table 4.6, respondents strongly agree with the physical layout of the network, reflected in a weighted mean of 4.33. IT experts and ICT coordinators unanimously confirmed that the network floor plan meets the connectivity needs of the Cauayan City Hall building (mean: 4.33). The design also received high ratings for effectively addressing scalability requirements (mean: 4.4) and ensuring easy accessibility for networking connections and equipment (mean: 4.33). Furthermore, the design facilitates seamless scalability to accommodate future growth and modifications (mean: 4.35).

The physical layout of a network is a critical factor in ensuring its efficiency and reliability. According to Tanenbaum and Wetherall (2011), a well-planned network layout minimizes interference and optimizes data flow, which is essential for maintaining high levels of connectivity. Studies on systems by Cisco (2020) emphasized the importance of adhering to structured cabling standards to ensure network durability and scalability.

Table 4.7 Network Map

QUESTIONS	AVERAGE	DESCRIPTION
1. The network map is easy to understand and interpret.	4.4	STRONGLY AGREE
2. The network map is regularly updated to reflect changes in the network.	4.33	STRONGLY AGREE
3. The network map includes all network devices and their connections.	4.33	STRONGLY AGREE
MEAN	**4.35**	**STRONGLY AGREE**

Referring to Table 4.7, respondents strongly agree on the effectiveness of the network map, as evidenced by a weighted mean of 4.4. Specifically, they find the map easy to comprehend and interpret (mean: 4.33) and appreciate its regular updates, which is accurately reflect changes in the network (mean: 4.33). Furthermore, participants strongly agree that the network map is comprehensive, encompassing all network devices and their connections (mean:4.35).

According to a study network map is an essential tool for effective network management, providing a graphical representation of all network devices, their connections, and topology. According to Marcus and Chou (2018), clear and comprehensive network diagrams simplify troubleshooting, enhance monitoring, and improve overall network efficiency. Similarly, Cisco (2020) highlights that well-documented network maps enable IT administrators to identify bottlenecks, optimize resources, and plan for future expansions effectively.

Table 4.8 IP Address Structure

QUESTIONS	AVERAGE	DESCRIPTION
1. The IP addressing structure is designed to easily meet scalability and growth requirements in the future.	4.8	STRONGLY AGREE
2. Efficient IP address subnetting is applied to improve the overall performance of the network.	4.0	STRONGLY AGREE
3. The IP addressing structure supports efficient routing of network traffic.	4.6	STRONGLY AGREE
MEAN	**4.47**	**STRONGLY AGREE**

Referring to the table 4.8, respondents strongly agree on the effectiveness of the IP addressing structure evidence by a weighted mean of 4.47. Respondents agree that the proposed IP structure easily meet scalability and growth requirement in the future (mean: 4.8). Respondents also agree that the IP address sub-netting is applied for overall performance of the network (mean: 4.0. Efficient routing of network traffics of the IP address structure also receives a high rating with a mean of (mean:4.6).

Chuck Semeria (1996) noted that the first problem is concerned with the eventual depletion of the IP address space. While this may appear to be a vast number of addresses, the growing demand from emerging markets and an increasing portion of the global population requiring IP addresses will eventually deplete the limit supply.

Table 4.9 Network Security and Processes

QUESTIONS	AVERAGE	DESCRIPTION
1. The network security measures in place are adequate and effective.	4.2	Strongly Agree
2. The network security measures protect against both internal and external.	4.4	Strongly Agree
3. Network security do not unnecessarily hinder network performance or usability.	4.5	Strongly Agree
Mean	**4.37**	**Strongly Agree**

According to Table 4.9, respondents strongly agree (weighted mean: 4.2) that the network's security measures are both effective and sufficient. These measures are rated highly for protecting against internal and external threats (4.4), while maintaining network performance and usability (4.5). Baum and Dawes (2017) highlight that effective security systems integrate components that automatically extract and transfer security data between controllers, ensuring seamless operation and enhanced protection.

Table 4.10 Devices connected in the network

Criterions	Mean	Interpretation
Devices connected to the network communicate efficiently with each other.	4.2	Strongly Agree
The network ensures secure connections for devices, protecting against unauthorized access or threats.	4.4	Strongly Agree
Managing of network devices are effective and efficient.	4.5	Strongly Agree
Mean	**4.37**	**Strongly Agree**

As shown in Table 4.10, respondents Strongly Agree regarding network-connected devices with the weight mean of 4.80. Respondents indicate strong confidence in the efficient communication of network-connected devices (4.8), and they highlight the network's commitment to secure connections, preventing illegal access or threats (4.60). Furthermore, everyone agrees on the effectiveness and efficiency of handling network devices (5.0).

Janko Ahlbrandt, and Rainer Tohrig (2013), stated that the number of involved proprietary protocols and interface-definitions complicates the risk management, if just for the number of involved manufacturers. Identified risks could all be addressed and could not block the setup's deployment. Risk management creates an extra effort, but can reduce harm and potential financial liabilities.

Table 4.11 Miniature

Criterions	Mean	Interpretation
The miniature presented by the researcher match the actual infrastructure of Cauayan City Hall building	4.90	Strongly Agree

The cable connection in the miniature and cable in the packet tracer complement each other.	4.80	Strongly Agree
The miniature shows effective cable management, minimizing clutter and ensuring safety.	4.80	Strongly Agree
Weighted Mean	**4.83**	**Strongly Agree**

In Table 4.11 shows that IT experts and ICT coordinators, as respondents, strongly agree (weighted mean: 4.83) with the presented miniature. They confirm its correctness in representing the actual Cauayan City Hall infrastructure (4.90) and the ideal alignment between cable connections in the miniature and Cisco Packet Tracer (4.80). Additionally, there is a shared acknowledgment of the miniature's effectiveness in showcasing well-managed cables, ensuring both neatness and safety (4.80).

Table 4.12 Result of Simulation

Questions	**Mean**	**Interpretation**
The routing path from the server to the client is accurately illustrates in the simulation.	4.70	Strongly Agree
The routing path from the client to the server is accurately illustrates in the simulation.	4.90	Strongly Agree
Data is securely transmitted between the client and server.	4.80	Strongly Agree
The server handles multiple client requests efficiently.	4.80	Strongly Agree
Mean	**4.80**	**Strongly Agree**

Tables 4.12 shows that respondents Strongly Agree with a weighted mean of 4.80. Particularly, respondents strongly agree that the simulation accurately reflects both the serverto-client (4.70) and client-to-server (4.90) routing pathways. Furthermore, there is a strong confidence in the secure transfer of data (4.80) and the server's effective processing of simultaneously client requests (4.80). The results indicate a strong agreement and satisfaction with the simulation's performance.

Table 4.13 Summary of Mean using Network Infrastructure Design Questionnaire

Criterions	**Mean**	**Interpretation**
Physical Layout	4.33	Strongly Agree
Network Map	4.35	Strongly Agree
IP Address structure	4.49	Strongly Agree
Network Security and Processes	4.35	Strongly Agree
Devices connected in the network	4.35	Strongly Agree
Miniature	4.64	Strongly Agree
Result of Simulation	4.72	Strongly Agree
Mean	**4.41**	**Strongly Agree**

Table 4.13 summarizes the mean ratings and descriptive interpretation of the proposed network infrastructure design. The result showed that the IT Experts, Teachers and ICT Coordinator *strongly agree* that the proposed Network Infrastructure Design of

Network Infrastructure Assessment: A Basis for Enhanced Network Design

Cauayan City Hall is usable and feasible in terms of its physical layout, network map, IP address structure, network security and processes, devices connected in the network, miniature, and simulation result with a general mean of 4.41.

Cost-Benefit Analysis

This section examines the potential cost savings and various benefits associated with implementing a star topology design.

Material Cost:

This section evaluates the financial implications of implementing the network infrastructure at Cauayan City Hall, focusing on the cost-effectiveness of the proposed network design.

Table 4.14 Hardware Cost of Network Infrastructure Design in Cauayan City Hall

Material	Unit	Price	Total Price
Router	1	₱ 8,349.04	₱ 8,349.04
Managed Switch TP-Link TL-SG108PE	1	₱15,846.06	₱15,846.06
Switch Cisco Catalyst 2950 24-PORT 10/100 Fe	14	₱8,102.00	₱43,428.00
Access point/ WIFI Ubiquiti Networks UniFi AP LR WiFi PoE Wireless Access Point	14	₱ 6,999.00	₱97,986.00
UTP Cable	2,000m	₱ 65.00	₱120,000.00
RJ45 Cat6 100 pcs per box	3	₱ 964.98	₱2,894.94
Patch Outlet/ RJ45 double socket	13	₱ 290.02	₱3,770.26
Server TERRAMASTER T9-450 9Bay NAS Storage - High Speed Network Attached Storage with Atom C3558R Quad-core CPU, 8GB DDR4 Memory, Dual SFP+ 10GbE Interfaces, Dual 2.5GbE Ports, NAS Server (Diskless)	1	₱ 26,799.00	₱ 260,799.00
Total			₱623,072.36

Note: The prices provided are sourced from iPrice and are subject to change based on the time and date of the data collection.

Table 4.15 Labor Cost of Network Infrastructure Design in Cauayan City Hall

Role	Unit	Daily rates	Number of days	Total
Network Administrator	3	₱ 863.00	90	₱ 77,670
Network Technician	4	₱ 520.00	90	₱46,800

Note: The prices provided are sourced from iPrice and are subject to change based on the time and date of the data collection.

Benefits:

The network infrastructure of Cauayan City Hall, built with a tree topology provides several significant benefits to Cauayan City Hall. These benefits include:

- The hierarchical structure allows easy expansion by adding new branches without disrupting the existing network.
- Combines the advantages of both star and bus topologies, minimizing redundant connections and hardware expenses.

- Centralizes control enables easier troubleshooting and network management.
- Aids in identifying additional hardware to be needed in performing network design.

CHAPTER V
SUMMARY, CONCLUSION AND RECOMMENDATIONS

Summary

Currently, the Cauayan City Hall has 10 routers in each department and offices, and it has a star topology network setup. However, this configuration presents several challenges, including limited scalability, inefficient performance, and restricted access to critical online resources. Additionally, the absence of centralized network control hinders effective traffic management, optimization, and troubleshooting. Study aims to address these problems by providing a strategic design and solution.

The functionality and practicality of the proposed network infrastructure design for the Cauayan City Hall were evaluated using the weighted mean and descriptive interpretation methods. The assessment involved 15 IT specialists who participated in the evaluation process.

The suggested network infrastructure design uses Cisco Packet Tracer simulation to prioritize planning and designing for efficient networking development, based on the PPDIOO paradigm. This aligned approach covers five of the six phases (Prepare, Plan, Design, Operate, and Optimize) with the exception of the implementation step. This makes it possible to conduct a focused and substantial simulation-based study on network modeling.

The proposed network infrastructure design leverages Cisco Packet Tracer simulation to prioritize effective planning and design for efficient network development, following the PPDIOO paradigm. This approach encompasses five of the six phases—Prepare, Plan, Design, Operate, and Optimize—excluding only the implementation phase. This methodology enables a focused and comprehensive simulation-based study of network modeling.

The study examines the existing network infrastructure at Cauayan City Hall and proposes an optimized design aimed at addressing several issues impacting network performance. The current hardware setup includes 12 printers, 10 routers, 15 switches, and 193 computers, each with varying specifications. While the system supports the daily operations of the City Hall, several hardware limitations, including insufficient printers, under-performing routers, and outdated devices, are identified. Additionally, the existing star topology proves inefficient, leading to congestion and higher operational costs. To enhance performance, the study proposes a shift to a tree topology, with upgrades to hardware such as high-capacity routers, switches, and centralized printers, alongside a more robust network layout. Furthermore, the use of VLANs, port security, and Wi-Fi 6 is recommended for improving both network security and connectivity.

The study utilized a custom-developed Network Infrastructure Design Questionnaire (NIDQ) to assess the feasibility and usability of the proposed network infrastructure. IT Experts and ICT Coordinators evaluated various aspects of the design, with the majority expressing strong agreement on key components: Physical Layout (4.33), Network Map (4.35), IP Address Structure (4.70), Network Security and Processes (4.49), Devices Connected in the Network (4.35), Miniature (4.64), and Simulation Results (4.72). The overall evaluation reflected a very positive reception, resulting in a weighted grand mean of 4.41.

Conclusion

The proposed hardware upgrades are designed to address the various limitations currently observed in the infrastructure at City Hall, aiming to significantly improve network efficiency, scalability, and overall performance. At present, the network struggles with several bottlenecks, including a limited number of printers, routers with insufficient capacity, and outdated switches. These limitations result in frequent delays, network congestion, and difficulties when scaling the infrastructure to accommodate the growing demands of City Hall's operations. The primary objective of the proposed upgrades is to modernize the entire network system, enhance performance, and support future expansion in a more efficient and cost-effective manner.

One of the key components of the proposal is the introduction of centralized, highcapacity network printers. Currently, the network printers are spread across multiple departments, causing delays due to heavy usage and inefficient management. By consolidating the printers into a single, high-capacity unit, the proposal aims to reduce printer queue times by up to 50%. This change will enable faster printing processes, reduce waiting times, and improve productivity across departments, particularly for tasks involving large print volumes. In addition to the printers, the proposal includes upgrading the routers to models with at least 2GB of RAM, which will significantly improve their ability to handle peak traffic loads and support the growing demand for internet access in a high-traffic environment. The upgraded routers will enable a much smoother network experience, improving connectivity and reducing latency by threefold during periods of heavy usage.

Further improvements will be made to the network's switches. The current switches are low-port models that are no longer suitable for the expanding number of connected devices in City Hall. The proposal calls for replacing these with higher-

capacity, modern switches capable of managing larger volumes of data. These switches will facilitate better data transmission speeds, increase network stability, and provide additional scalability, allowing the network to grow without requiring significant further investment in hardware. With these upgraded switches in place, the network will be better equipped to handle future expansions without running into performance issues.

Additionally, the proposal suggests implementing a centralized server for managing data storage and resource sharing across departments. This centralized approach will not only streamline data access but also reduce the dependence on multiple routers. By consolidating data and applications onto a single server, network management becomes more straightforward, and troubleshooting issues becomes less complicated. Centralized storage will also enable more efficient data backup processes and provide a more secure environment for sensitive City Hall data.

Finally, the proposal includes upgrading the computers used across various departments to Solid-State Drives (SSDs), which are known for their speed, durability, and energy efficiency. This upgrade will significantly improve the responsiveness of applications, speed up data retrieval times, and extend the lifespan of the computers. Furthermore, the proposal calls for standardizing the computer specifications across departments to ensure consistency and ease of maintenance. By ensuring that all computers are equipped with similar specifications, troubleshooting becomes easier, and employees will experience uniform performance levels, contributing to a smoother workflow.

RECOMMENDATION

Based on the results of the study, the researchers recommended the following:

1. Future researchers may investigate the impact of 5G technology on educational network infrastructures, exploring how faster and more reliable connected networks could influence the design and functionality of future systems.
2. Future Researchers are encouraged to explore emerging technologies in network infrastructure to ensure that proposed designs remain flexible and capable of incorporating future advancements in the field.
3. Future researchers are recommended to conduct in-depth studies on the scalability of network infrastructure designs to accommodate potential expansion needs, ensuring that the framework can support future growth and adapt to changes.

REFERENCES

1) Afrin, T., & Yodo, N. (2019). Resilience-Based Recovery Assessments Of Networked Infrastructure Systems Under Localized Attacks. *Infrastructures*, *4*(1), 11. Https://Doi.Org/10.3390/Infrastructures4010011
2) Ahmed, A. H., & Al-Hamadani, M. N. A. (2021). Designing a Secure Campus Network And Simulating It Using Cisco Packet Tracer. *Indonesian Journal Of Electrical Engineering And Computer Science*, *23*(1), 479. Https://Doi.Org/10.11591/Ijeecs.v23.i1.Pp479-489
3) Ahmad, A. H. (2022). Challenges And Effectiveness Of Using Cisco Packet Tracer Simulator In Learning Vpn Connection (Virtual Private Network). International Journal Of Modern Education, 4(14), 21–30. Https://Doi.Org/10.35631/Ijmoe.414003
4) Alaoui, I. E., & Gahi, Y. (2020). Network Security Strategies In Big Data Context. *Procedia Computer Science*, *175*, 730–736. Https://Doi.Org/10.1016/j.Procs.2020.07.108
5) Annigeri1, S ., Chauhan, A ., & Chhatlan, J. (2020). Use Of Virtual Lans For Network Segmentation And Organization. *International Journal Of Research In Engineering, Science And Management (Ijresm).*
6) Azamuddin, W. M. H., Hassan, R., Aman, A. H. M., Hasan, M. K., & Al-Khaleefa, A. S. (2020). Quality Of Service (Qos) Management For Local Area Network (Lan) Using Traffic Policy Technique To Secure Congestion. *Computers*, *9*(2), 39. Https://Doi.Org/10.3390/Computers9020039
7) Basu, D. (2019). Network Infrastructure Vulnerabilities And Its Mitigation: A Review.
8) Cerdà-Alabern, L., Iuhasz, G., & Gemmi, G. (2023). Anomaly Detection For Fault Detection In Wireless Community Networks Using Machine Learning. *Computer Communications*, *202*, 191–203. Https://Doi.Org/10.1016/j.Comcom.2023.02.019
9) Cherifi, H., Palla, G., Szymanski, B. K., & Lu, X. (2019). On Community Structure In Complex Networks: Challenges And Opportunities. *Applied Network Science*, *4*(1). Https://Doi.Org/10.1007/s41109-019-0238-9
10) Chunaev, P. (2020). Community Detection In Node-Attributed Social Networks: A Survey. *Computer Science Review*, *37*, 100286. Https://Doi.Org/10.1016/j.Cosrev.2020.100286
11) Chunaev, P., Nuzhdenko, I., & Bochenina, K. (2019). Community Detection In Attributed
12) Cuppens, F., Cuppens-Boulahia, N., & García, J. (2019). Misconfiguration Management Of Network Security Components. *Arxiv, Abs/1912.07283*.

13) Dao, N., Pham, Q., Tu, N. H., Thanh, T. T., Bao, V. N. Q., Lakew, D. S., & Cho, S. (2021).
14) Gan, Q., Xiao, F., Qin, Y., & Yang, J. (2019). Fixed-Time Cluster Synchronization Of Discontinuous Directed Community Networks Via Periodically Or Aperiodically Switching Control. *Ieee Access*, *7*, 83306–83318. Https://Doi.Org/10.1109/Access.2019.2924661
15) Gaurkar, C., & Thul, K. (2023). College Campus Network Scenario Design & Implementation By Using Cisco Packet Tracer. *International Research Journal Of Modernization In Engineering Technology And Science* Https://Doi.Org/10.56726/Irjmets34445
16) Gк, N. O., Gt, N. D., & N, N. R. (2020). Design and Simulation of Virtual Local Area Network Using Cisco Packet Tracer. *Bulletin of The* National Academy of Sciences of The Republic Of Kazakhstan (The *Bulletin)*, *6*(388), 6–14. Https://Doi.Org/10.32014/2020.2518-1467.176
17) Gudapati, N. V. C., Malaguti, E., & Monaci, M. (2022). Network Design With Service Requirements: Scaling-Up The Size Of Solvable
18) Hayudini, M. A. (2021). Network Infrastructure Management: Its Importance To The Organization. *Natural Sciences Engineering And Technology Journal*, *2*(1), 80–86. Https://Doi.Org/10.37275/Nasetjournal.v2i1.15
19) Hossain, M. A., & Zannat, M. (2019). Simulation And Design Of University Area Network International Journal For Research In Applied Science And Engineering Technology, 7(5), 842–846. Https://Doi.Org/10.22214/Ijraset.2019.5142
20) Kumar, A., Perveen, S., Singh, S., Kumar, A., Majhi, S., & Das, S. K. (2021). 6th Generation: Communication, Signal Processing, Advanced Infrastructure, Emerging Technologies And Challenges. *2020 5th International Conference On Computing, Communication And Security (Icccs)*. Https://Doi.Org/10.1109/Icccs51487.2021.9776334
21) Kunneke, R., Ménard, C., & Groenewegen, J. (2021). Network Infrastructures. In *Cambridge University Press Ebooks* (Pp. 15–42). Https://Doi.Org/10.1017/9781108962292.004
22) Framework For Critical Infrastructure Networks' Interdependencies. *Water Science & Technology*, *81*(7), 1420–1431. Https://Doi.Org/10.2166/Wst.2019.367
23) Matisziw, T. C., & Murray, A. T. (2019). Modeling – Path Availability To Support Disaster Vulnerability Assessment Of Network Infrastructure. *Computers & Operations Research*, *36*(1), 16–26. Https://Doi.Org/10.1016/j.Cor.2007.09.004
24) Melnikova, O. K., Yahin, M. A., Burenkova, O. M., Makayev, K. F., & Makayeva, G. Z. (2020). Internet Communication: Architecture And Typology Of Digital Folklore. Iop Conference
25) Osman, A. M. S. (2018). A Novel Big Data Analytics Framework For Smart Cities. *Future Generation Computer Systems*, *91*, 620–633. Https://Doi.Org/10.1016/j.Future.2018.06.046
26) Osman, M. N., Sedek, K. A., Othman, N. A., Rosli, M. A., & Maghribi, M. (2021). Enhancing Security And Privacy In Local Area Network (Lan) With Torvpn Using Raspberry Pi As Access Point: A Design And Implementation. *Journal Of Computing Research And Innovation*, *6*(2), 29–40. Https://Doi.Org/10.24191/Jcrinn.v6i2.190
27) Problems. *Informs Journal On Computing*, *34*(5), 2571–2582. Https://Doi.Org/10.1287/Ijoc.2022.1200
28) Radosavovic, I., Kosaraju, R. P., Girshick, R., He, K., & Dollar, P. (2020). Designing Network Design Spaces. 2022 Ieee/Cvf Conference On Computer Vision And Pattern Recognition (Cvpr). Https://Doi.Org/10.1109/Cvpr42600.2020.01044
29) Ramdhania, A. N., Kurniawan, M. T., & Hediyanto, U. Y. K. S. (2019). Network Infrastructure Design In Connectivity Using Inter-Vlan Concept In Bandung District Government. *Acm Digital Library*, 111–115. Https://Doi.Org/10.1145/3369555.3369562
30) Rashid, N. B. A., Othman, M. Z. B., Johan, R. B., & Sidek, S. F. B. H. (2019). Cisco Packet Tracer Simulation As Effective Pedagogy In Computer Networking Course. *International Journal Of Interactive Mobile Technologies (Ijim)*, *13*(10),4. Https://Doi.Org/10.3991/Ijim.v13i10.11283
31) Scenario (Uans) Using Cisco Packet Tracer. Global Journal Of Computer Science And Technology, 7–11. Https://Doi.Org/10.34257/Gjcstgvol19is3pg7
32) Shaffer, G. (2020b). Community Wireless Networks. *Wiley Online Library*, 254–267. Https://Doi.Org/10.1002/9781119537151.Ch19
33) Social Networks: a Unified Weight-Based Model And Its Regimes. *2021 International Conference On Data Mining Workshops (Icdmw)*, 455–464. Https://Doi.Org/10.1109/Icdmw.2019.00072
34) Sowjanya, N. L. (2020). An Efficient Vlan Implementation to Decrease Traffic Load In a Network. International Journal of Advanced Trends In Computer Science And Engineering, 9(2), 2147–2153. Https://Doi.Org/10.30534/Ijatcse/2020/189922020
35) Series Materials Science And Engineering, 890, 012212. Https://Doi.Org/10.1088/1757-899x/890/1/012212

36) Survey On Aerial Radio Access Networks: Toward a Comprehensive 6G Access Infrastructure. *Ieee Communications Surveys & Tutorials*, *23*(2), 1193–1225. Https://Doi.Org/10.1109/Comst.2021.3059644
37) Requirements: Scaling-Up The Size Of Solvable Problems. *Informs Journal On Computing*, *34*(5), 2571–2582. Https://Doi.Org/10.1287/Ijoc.2022.1200
38) Sengupta, S., Chowdhary, A., Sabur, A., Alshamrani, A., Huang, D., & Kambhampati, S. (2020). A Survey Of Moving Target Defenses For Network Security. *Ieee Communications Surveys & Tutorials*, *22*(3), 1909–1941. Https://Doi.Org/10.1109/Comst.2020.2982955
39) Udo, E., Isong, E., & Nyoho E. (2020). Software Defined Networking Framework For Campus Network Management. *International Journal Of Computer Science And Network (Ijcsn).*
40) Wang, C., Liao, H. M., & Yeh, I. (2022). Designing Network Design Strategies Through Gradient Path Analysis. *Arxiv (Cornell University)*. Https://Doi.Org/10.48550/Arxiv.2211.04800
41) Zhang, Z., Deng, Y., Min, G., Xie, J., Yang, L. T., & Zhou, Y. (2018). Hsdc: a Highly Scalable Data Center Network Architecture For Greater Incremental Scalability. *Ieee Transactions On Parallel And Distributed Systems*, *30*(5), 1105–1119. Https://Doi.Org/10.1109/Tpds.2018.2874659
42) Zheleznyak, O. (2021). Network Infrastructure In The Present-Day Realities. *Проект Байкал*, *70*, 78–83. Https://Doi.Org/10.51461/Projectbaikal.70.1893

APPENDIX A:USER MANUAL

This section provides step-by-step instructions on accessing and downloading the Cisco Packet Tracer file (CauayanCityHall_Simulation.pkt) using a direct link.

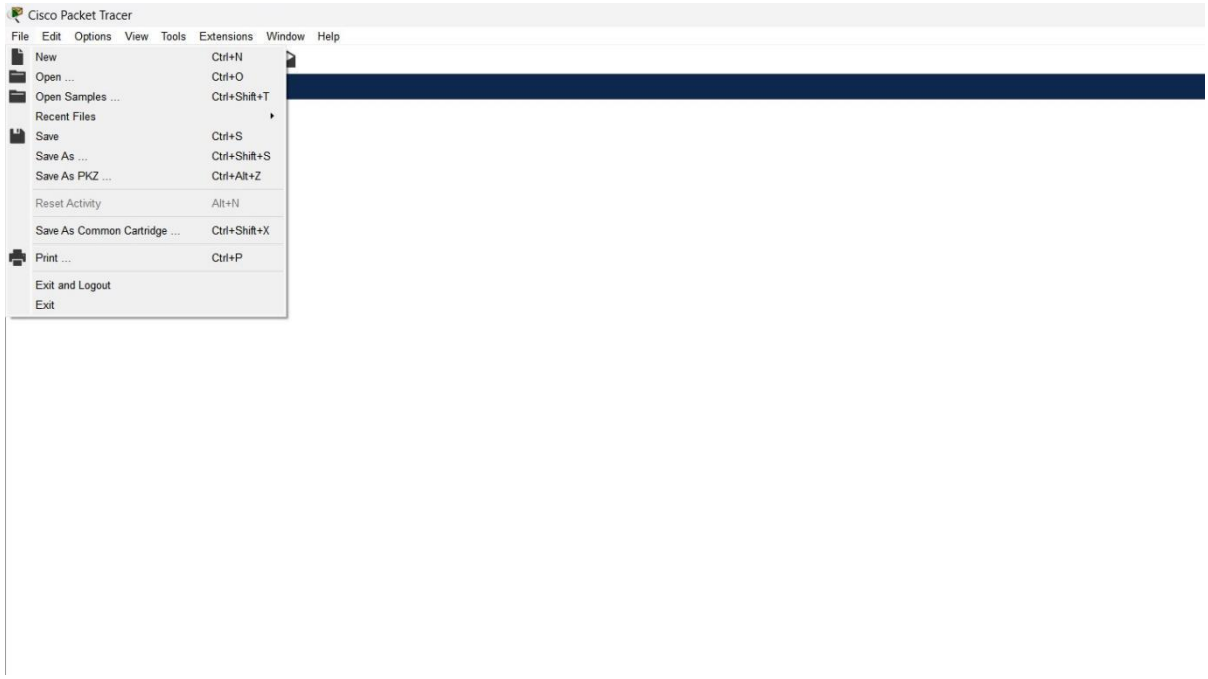
Steps:

Download CauayanCityHall_Simulation.pkt:

Download the Cisco Packet Tracer file using this link: https://bit.ly/3PJBti3 **Open Cisco Packet Tracer**:

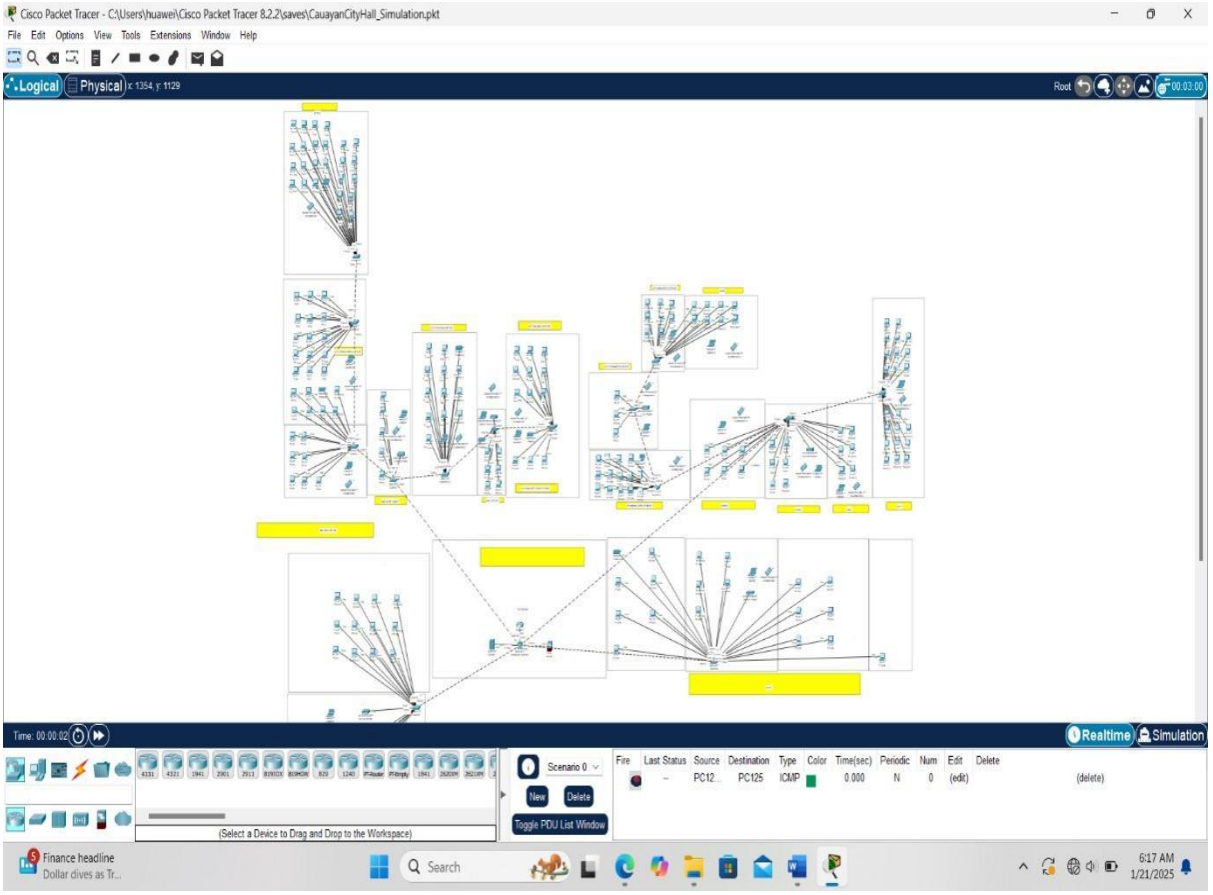
Launch the Cisco Packet Tracer version 7.3.0 on your computer. Select “Guest Login” Button.

Load the Simulation: In Cisco Packet Tracer, go to the "File" menu. Select "Open" and browse to the location where you saved "CauayanCityHall_Simulation.pkt."



Explore the Simulation:

Once loaded, explore the simulation by navigating through different devices and configurations.



APPENDIX B: MINIATURE

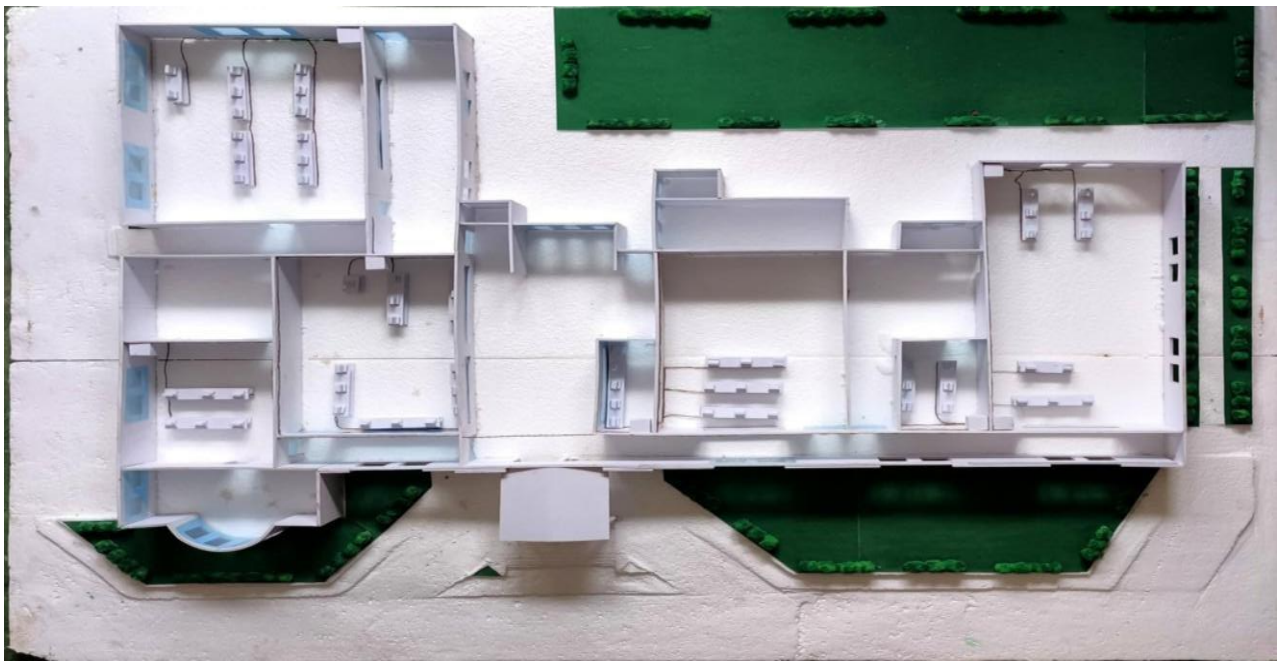
Miniature

This design shows how the proposed network design was built and how it functions.

Model design for Cauayan City Hall

Figure 14. Model design for Cauayan City Hall

Model design for first-floor Cauayan City Hall



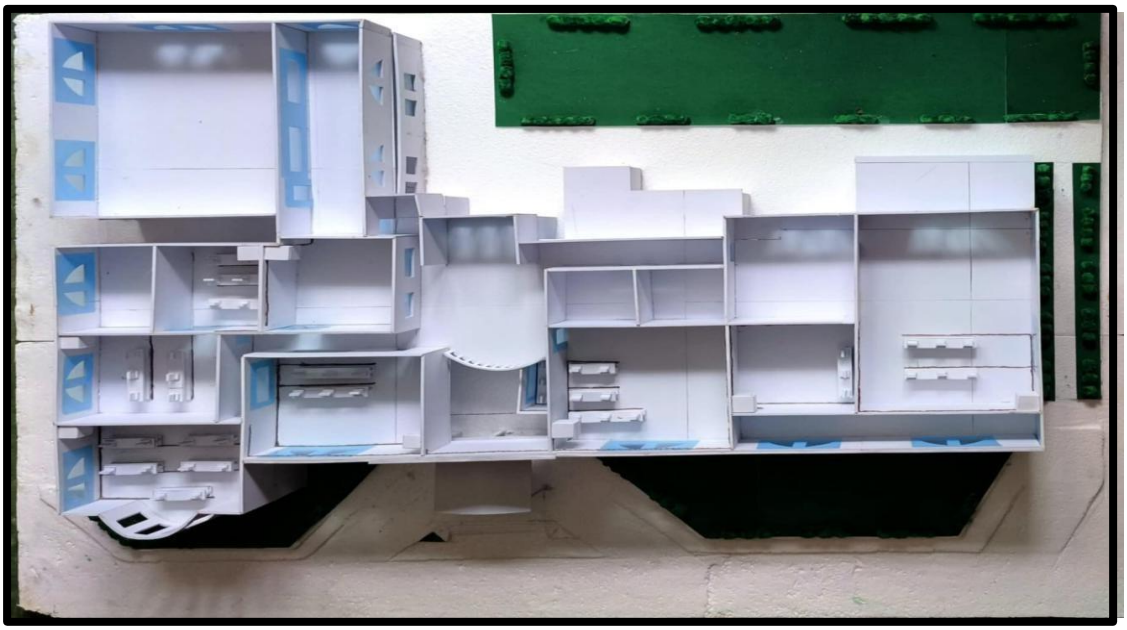


Figure 15. Model Design for Second Floor of Cauayan City Hall

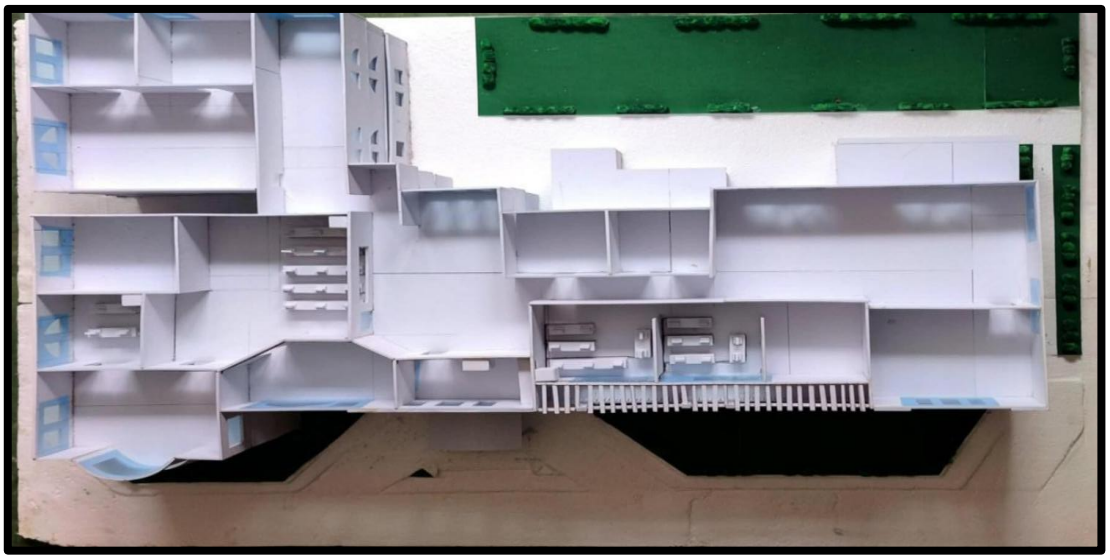


Figure 16. Model Design for Third Floor Cauayan City Hall