# Proposing a Framework for Enabling Network Performance Optimization: A Case Study of Addis Ababa Public Services and Human Resource Bureau

**A Thesis presented**

**By**

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**In**

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# ACCEPTANCE

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**Accepted by the Faculty of Informatics, St. Mary's University, in partial fulfillment of the requirements for the degree of Master of Science in Computer Science**

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# DECLARATION

I, the undersigned, declare that this thesis work is my original work, has not been presented for a degree in this or any other universities, and all sources of materials used for the thesis work have been duly acknowledged.

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This thesis has been submitted for examination with my approval as advisor.

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Thank you,

Tigist Degineh

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## List of Acronyms

| | |
|---|---|
| AA | Addis Ababa |
| ARP | Address Resolution protocol |
| VPN | Virtual Private Network |
| ICMP | Internate control Message Protocol |
| ICSMIS | Integrated Civil service Management Information System |
| ICT | Information communicationTechnology |
| TVT | Technical Vocational Traning |
| IP | Internate Protocol |
| ITU | International Telecommunications Union |
| KPIS | key performance indicators |
| LAN | Local Area Network |
| ACK | Acknowledged |
| ISP | International Service Provider |
| VMDK | Virtual Machion Disk Format |
| QOS | Qualty of service |
| OPNET | Optimized Network Engineering Tools |
| RTT | Round Trip Time |
| TCP | Transport Control Protocol |
| UDP | User Datagram protocol |

| | |
|---|---|
| WAN | Wide Area Network |
| WLAN | Wireless Lan |

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# Abstract

Network performance is paramount for ensuring quality service delivery within organizations. However, the Addis Ababa Public Services and Human Resource Bureau face challenges stemming from outdated network devices, configuration issues, and suboptimal network design, resulting in poor network performance characterized by delays and limited availability. This study aims to propose a framework for enabling network performance optimization within the bureau. Through observation of the current network infrastructure, conducting interview & questioner with targeted ICT users, and analysis of network traffic using Wireshark, key metrics such as packet loss, response time, latency, round-trip time (RTT), bandwidth usage, and network availability were assessed. Subsequently, a comprehensive framework for network performance improvement was developed based on the study findings.

**Keyword**: Quality of Service, Metrics, and Ethernet interface, ICT expert, Network Traffic, optimization framework.

# CHAPTER ONE

# 1 INTRODUCTION

## 1.1 Background

Networking is a network that permits sharing of information and transfer between a number of devices. Hardware, such as routers, modems, computers, servers, network firewalls, switches that are needed, and gateways, link together to establish networks of computers. These gadgets have both wireless and physical connectivity. A across the globe computer network called the Internet [29]. Here thousands of millions of individuals all over the globe are linked to the global Internet as a collaborative, autonomous, freely accessible resource. That is employed to share content on social networking and as a way to consume information. It has encouraged its own social ecosystem to grow. Social media is essential for gathering and sharing information, but it also increases bandwidth usage, which reduces network performance.

For the network to function effectively and efficiently, many conditions must be met. The order in which they rank greatest is performance, throughput, delay, and security [1]. Misuse of the network, unstable connections, and a decrease in internet speed are just a few of the numerous network issues that arise when we utilize the network. As a result, it becomes essential to keep an eye on network traffic to make sure everything is running efficiently [2].

This research focuses on Addis Ababa public services and the human resource bureau network environment. Currently, Addis Ababa public services and human resources network used to provide complaint submission services to the City Administrative Court for sub-cities, woreda employees. In addition to complaint submission services, it is also used for ICSMIS (Integrated Civil Service Management Information System) services from the Federal Public Service Ministry's using WordNet VPN (virtual private network) network services.

AA Public Services and Human Resources bureau Network handles 12 floors by containing many users, which work in three different sectors of bureaus. This leads to different network problems in terms of network speed, availability, and divisibility.

## 1.2 Motivation

Configuration errors, inadequate framework and design, and a lack of primary maintenance are the main causes of the decline in network performance.

In the line above paragraph, Addis Ababa Public Service and Human Resource Bureau have a network, but network performances are reduced from time to time gradually, so the researcher is interested in studying the reason why the performance is reduced. Finally, the researcher tries to propose a network framework to enhance network performance for the Addis Ababa Public Service and Human Resources Bureau.

## 1.3 Statement of the problem

The Addis Ababa Public Service and Human Resources Bureau's duties include developing institutional capacity, identifying contemporary practices and methods that streamline work and implementing them in the city administration's offices, keeping an eye on performance, and offering the required technical and professional assistance. Also, it would guarantee that the local administration agencies offer services at the proper capacity. Information technology should thus assist it in order to guarantee the seamless and effective operation of office services. The field of information technology offers a few services. These are to have an optimized network to guarantee quick and dependable operational services and to have effective network access.

The current network infrastructure of the Addis Ababa public service and human resources bureau is slow, and there are interruption problems. To overcome this problem, identify the network performance status and optimize it to propose a better framework for the office. Network performance is determined by many factors. A few of the performance problems with networks are sluggish internet, hinders, west of information, redeliver information, high speed usage [2]. If the network speed is less than normal and the application access is not fast when using it, what do we call network lag. Latency is the time lag between the sender and the recipient of data. Users may find it challenging to access resources due to high latency, which can also lead to lags and a decline in network performance.

Information loss is the term used to describe the dropping of a data packet during transmission. The simultaneous use of resources by multiple users results in low response, network congestion, and a decline in network speed.

The Addis Ababa Public Services and Human Resource Bureau faces challenges related to suboptimal network performance, which hinder efficient operations and service delivery. These challenges include slow network speeds, frequent downtime, inadequate bandwidth, security vulnerabilities and inefficient resource utilization.

## 1.4 Research Question

Research questions that will direct the study are as follows:

RQ1. How can network performance be enhanced?

RQ2. What network framework will be proposed to improve network performance?

RQ3. How can the proposed framework be effectively validated?

## 1.5 Objective

### 1.5.1 General objective

The general objective of the study is to assess network performance and develop a suitable framework for optimizing network performance within the Addis Ababa Public Service and Human Resources Bureau.

### 1.5.2 Specific objective

To set the overall goal of the research, the following tasks must be done:

- To assess the problem of network performance in the case of a public service and human resources bureau.
- To improve network performance.
- To propose network performance optimization framework.
- To develop criteria for evaluating the effectiveness and suitability of the proposed framework.

## 1.6 Scope and limitations of the research

In our study without addressing application performance, the work's scope is restricted to the AA Public Service and Human Resources Bureau's performance-wired network. Data from organization network devices and responses from specific ICT specialists were gathered to analyze network performance.

The limitations of this study are as follows:

- The respondents can't deliver accurate data because of their ignorance.
- Due to time limitations and being unfamiliar with some devices, the researcher only used the Wireshark tool for data analysis.

## 1.7 Significance of the research /contribution

By optimizing network performance within the Addis Ababa Public Service and Human Resources Bureau, the research can enhance the efficiency and effectiveness of service delivery.

This could lead to faster response times, improved accessibility to government services. Regarding resource allocation a more efficient network can lead to better utilization of resources within the bureau. By identifying and addressing network performance issues, the bureau can allocate resources more effectively.

## 1.8 Organization of the study

There are five chapters in this research study. The study's background, research questions, problem statement, goal, particular goal, importance, and scope were all covered in the first chapter, or introduction. An overview of relevant literature on frameworks for network performance improvement and related studies is included in the second chapter. The study's methodology for the exploratory research design, sample frame, sampling procedures, data gathering strategies, and data analysis approaches were covered in the third chapter. The results and debate were the main topics of the fourth chapter. The fifth chapter included recommendations, findings, and ideas for more study.

# CHAPER TWO

# 2 LITERATURE REVIEW

## 2.1 Introduction

This chapter's primary goal is to provide a coherent theoretical and practical/empirical foundation for the main topic of the research. To fully comprehend the current research, the researcher has looked through a wide range of relevant literature sources, including books, journal articles, conference proceeding papers, and the Internet.

## 2.2 Network

A computer network consists of two or more connected devices that may share resources [1]. Nowadays, people may share information with another person anywhere in the world due to computer networking [11].

Email, the Internet, an online library, instant messaging, video and audio conversations are some of the few advantages that have arisen as a result of several computer devices being connected via wired or wireless connections[30][37]. Asset sharing is one of the preferences of computer systems. When utilizing computer systems for trade, any client or asset on the organization ought to be able to get information, equipment, and computer programs from anyplace within the world [33].

Utilizing remote or cable media systems, the gadgets can communicate with each other. In order for the information to be traded between the two, they must be physically associated with each other by a medium such as an electrical cable. In case the distance between two communication gadgets in an open or undertaking organization exceeds one kilometer, at that point optical filaments are ordinarily utilized to transmit information wirelessly [30] [37].

Depending on their distance, we classify computer systems as neighborhood region systems (LANs), which implies they interface and organize gadgets over a brief distance. [33] [11] [9]. As a rule, it is constrained to a single region, such as a building or instructive institution [16]. Due to low costs and poor application execution, conventional LAN-oriented frameworks are inadequate to encourage worldwide collaboration [14].

The term "metropolitan range organize" (MAN) depicts a strategy of interconnection organize gadgets over different towns. MAN, systems are more extensive than LANs and require the help of broadcast communications suppliers as implies of communication between computer systems. [33] [11] [9].

Enormous Region Systems, or WANs, which have been made to associate computer systems that span a gigantic topographical locale through utilize of profoundly complex equipment. As compared to MAN and LAN systems [33] [14] [11]. Connect systems over advance separations. Satellite uplinks or specialized transoceanic cables may be utilized to interface together such sorts of worldwide arrange [16] [9].

A common set of guidelines and signals that computers on a network use to interact are specified by protocol [9]. Ethernet is used by most networks. Ethernet is a competition media access technique that enables a network's hosts to share a link's bandwidth.

The terms "architecture" applies the two main kinds of network architecture: via peer-to clients and servers [9]. These networks rely on machines connecting to one another for sharing documents, printing device, including internet access; they have no need for a server every desktop or laptop joins to an NT The domain controller. This may offer network safety while providing a host of other services, such as including electronically mail), the sharing of files, printing availability, and remotely handled internet access

### 2.2.1 Essential Elements of a Computer Network

Links and devices for networking which is the computer networking's principal structural elements. Any number of nodes can be connected using these connections. Communication standards describe the information interchange methods across these kinds of networks. Interaction terminals, which are also knowns as ports [35].

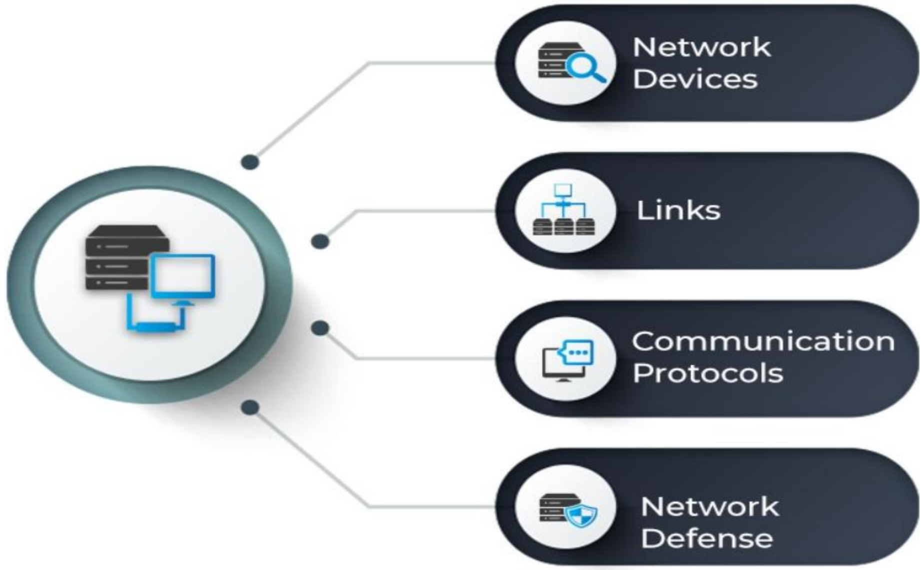


*Figure 2.1 Important Computer Network Components [35].*

#### 2.2.1.1 Network Devices (Nodes)

Nodes, sometimes referred to as network devices that are computing units which need a network connection in order to operate. Computers, switches, routers, and servers are a few examples of various sorts of network equipment [35] [30]. Network equipment is the actual hardware which allows conversation and physical interaction via the computer network [39].

Network devices offer fast, precise, and fast transfer of data across networks. Network devices that are found in computers are mostly of two types: hubs, that connect multiple devices in a network and send broadcasts to destination endpoints, switches, which route messages to the appropriate place and identify the intended device by looking at the packet's mac address information, a router is a device that connects networks together. A gateway that allows devices to connect to a local area network via a wireless network device is an access point. A bridge joins two local area networks (LANs) to create a single network [39].

#### 2.2.1.2 Links

Physical cable links and wireless ones are the two sorts of links. Telephone lines, coaxial wires, fiber optics, and twisted-pair wiring are examples of tangible wire linkages. Wireless, for short, implies Connections to networks may also be established via radio as well as other electromagnetic waves [35] [30].

#### 2.2.1.3 Protocol for networks communication

A group of rules known as network protocols control the data flow between different nodes on the same network. Protocols are sets of rules for exchanging data between and inside computer systems as well as in telecommunications. They may include features like authentication, signaling, and error correction [38]. Protocols specify a standard set of rules and signals used by computers on a network to communicate. Despite differences in their underlying design, procedures, or structures, it permits communication between connected devices [18] [9] [10] [35].

Details on the identification of devices, connectivity setups, as well as additional communication protocols are included in a network protocol. Additionally, a variety of protocols employ compression of data as well as messages response for efficient and effective connection to the network [34].

#### 2.2.1.4 Network defense

The phrase "computer system protection" describes any action a business can take in order to stop external parties from exploiting its network of computers. Diverse technological safeguards, include electronic gates, network firewalls, and virtual private networks (VPN and more, may assist the company's) [35] [40].

## 2.3 Factors of network performance degradation

There are several performance metrics that should be used to gauge performance [36]. Applications running over a WAN may rapidly see a decline in performance due to a variety of issues that are not often present in local area networks (LANs) [14]. The high latency brought on by lengthy transmission distances, protocol translations, and network congestions is a hurdle in wide area networks [14]. One main cause of the extended application response time is the prolonged latency in the wide-area network. Transmit management protocol (TCP) serves as a transport layer protocol that is impacted by overcrowding; this results in unexpected behavior, repeated transmissions, and packets being lost. One of the problems that corporations face is data loss due to corruption or crashes of their current databases, so having a backup copy of your data on a different server is crucial[7].Numerous protocols do not function effectively in WAN conditions because the majority of existing protocols are not built for WAN situations [14].

Our usage of the Internet has increased recently. Even though it's critical that everyone use the Internet, some Internet users damage networks. The following network issues are listed. Misuse of networks, harmful connections and slowness of the internet possibly happen when using the network [2]. The expansion of communication channels and network technology has given rise to a number of problems that are adversely affecting the channel that the technology operates on. Virus, intrusion, and denial-of-service attack on network services are a few of those issues [8]. As information technology advances and data usage rises, the primary concern regarding speed and latency is growing degradation of network performance results from this [5]. Due to the rise of social media and other entertainment websites, there is a growing gap between the amount of bandwidth available to users and their demand, as network bandwidth usage rises daily[6].

The network performance can be impacted by clients transmitting zero windows because they are out of buffer space, applications generating too little data to populate the network, network congestion, buffer overflow, and bottleneck links' limited capacity. Throughput can be significantly reduced by a modest receive buffer [4].

The network's underperformance can be attributed to various factors, such as structural inequivalent, overloads, improper system tuning, and protocol overheads. These factors can lead to issues such as poor resource and link utilization, packet discards and errors, high device response times, and issues with ISP service availability [6]. The impact of network data on performance, including traffic, channel condition, and network architecture [31].

Network performance is greatly impacted by the devices' memory and CPU use [8]. The CPU utilization indicates the proportion of the device's entire capacity to its work load. Slow-performing networks with unresponsive router services are often associated with higher CPU make use of rates. Sluggish console response, nonexistent as well as slower ping reply, gateway that doesn't relay routing changes to different routers, excessive buffering rate of failure, and difficulty to Telnet with the router itself [8].

Memory is one resource that has an impact on a device's performance [8]. The memory utilization ratio of network devices shows how much data is being loaded into the device in relation to its entire capacity. A high memory utilization rate indicates that either there is an excessive amount of traffic or there is an issue with the packets' processing to get to their destination.

One of the difficulties facing network designers as computer networks expand exponentially faster is offering greater bandwidth and a more dependable connection [6]. Available bandwidth, network congestion, latency, server performance, and protocol overall all have an impact on network performance [6].

Numerous factors can contribute to network lagging, such as both software and hardware malfunctions, problems with network devices, configuration problems, and excessive use of the available media [6]. A delay problem will occur if the amount of data to be transferred surpasses the available bandwidth capacity [5]. Irregular delay time spikes or continuous delays are indicators of a serious performance issue. Several factors might be responsible for the delay in packet transfer. The primary delay problem that might occur in a local area network is bandwidth delay. Significant data loss occurs from high traffic congestion on the WAN network [5]. This will definitely affect how well employees use the data, which will eventually affect the success of the company as a whole [5].

Network topology, device configuration, and interface capacity are some of the elements that have a major impact on network performance [11]. The data path's latency and reliability will rise as additional network devices are added [9].

The types of protocols being used and the traffic moving over the network present problems for network performance [38]. A set of rules implemented on some devices that do not work with other network routing rules is another factor that could lead to issues [8]. Network performance is also impacted by routing protocols, and wide area network performance depends critically on choosing the optimal routing protocol [8].

## 2.4 Assessment of network performance

The network performance determines whether or not we can guarantee that an establishment offers high-quality services. Network performance metrics are essential for assessing how well an organization's network is performing. A computer network is measured and controlled using numerical parameters to measure its efficiency and reliability [7]. The parameters that we measure network performance are when data is successfully delivered to the desired address without interruption, how much data is transmitted in network a certain time, interruption before the data reaches the desired address, and data delay. For a wired, wireless network, the first things we should pay attention to are the performance parameters, which are network, collagen, data fragmentation, data delay, without any interruption when the data reaches the desired address [31].

### 2.4.1 Dropped packets

Using a wireless network, data drops when large amounts of data cannot reach the intended destination [31]. Ethernet users suffer from reduced throughput due to data loss and network congestion [32]. A data drop refers to the packets being dropped because the data delay is higher than the average [7].

Data corrupt can occur due to many conditions such as multipath drops effects signal decline across the network medium, congestion causing data drop, network device failure [10].

### 2.4.2 Data Transfer Speed

Network congestion affects network performance because congestion consumes more bandwidth and affects data rates [31]. All users of the service are affected in many ways due to unregulated bandwidth usage and access [6].

Another key performance indicator that measures data transfer speed and acceleration is called Available Bandwidth [6]. Available bandwidth metric is required to transfer large amounts of data. But Due to the high cost of connectivity, the available bandwidth is used much less than the delay metric.

We use the utilization parameter to measure the network function. The percentage of network capacity or the bandwidth we use at any given time is called the utilization rate [10]. Corporate communication is becoming more popular, and it relies heavily on rich media and live and on-demand video, which take a lot of bandwidth [7]. One basic result of scarce network resources, particularly router processing time and connection speed, has been defined as congestion. A major factor influencing network congestion is cumulative router processing time[10].Monitoring the network continuously is the greatest method to identify instances of overuse [6].

Oversubscription is a performance-related issue brought on by varying network bandwidth utilization. The lower rate portion of the network may become overcrowded when data is transferred from a higher rate network to a lower rate network [10]. Oversubscription slows down transmission by creating queues in the devices typically router that handle bandwidth changes [10].

Lack of enforcement of user access regulations has been observed, allowing users to download or upload personal media files during peak hours and depriving genuine users of bandwidth [11].

Three essential (and interrelated) elements of bandwidth management are implementation, monitoring, and analysis [13]. A policy is a declaration of views, goals, deeds, and protocols that direct how the network is used generally. The process of continuously gathering data about different facets of your network's activities is known as network monitoring. You can detect errors, instances of waste and improper access, and trends that might point to future issues by closely examining this data. The process of putting filtering, caching, and other technologies into your network to assist bring actual usage in line with policy is called implementation [13].

#### 2.4.3 Throughput

In the network, throughput indicates without any problem data successfully transmitted [6]. Relatively high throughput can be achieved using a local area network that has adequate bandwidth, low latency, and a low packet drop rate [8]. Only having excess bandwidth will not allow for a high throughput rate, but when combined with drop rate and latency, it can be a useful measure of network performance.

Excess amount of information available in the network node it may affect services reliability [10]. One of a factor of WAN problems issues are a large distance connections including data drop rate [14].

#### 2.4.4 Network lag

For modest data transmissions in particular, network lag may be used to assess network connection path performance directly [6]. The amount of time takes for a particular network node to replay to the request of a remote client may be determined based on response time, both sides. The dropouts of packet and network delays in the target node will occur with longer response times [6].

### 2.5 Administration of Networks

Network management entails setting up, evaluating, and debugging software, hardware, and connection challenges. The functional domains of network management consist of (user) accounting management, control of performance, safety management, configuration administration, and handling errors [35].

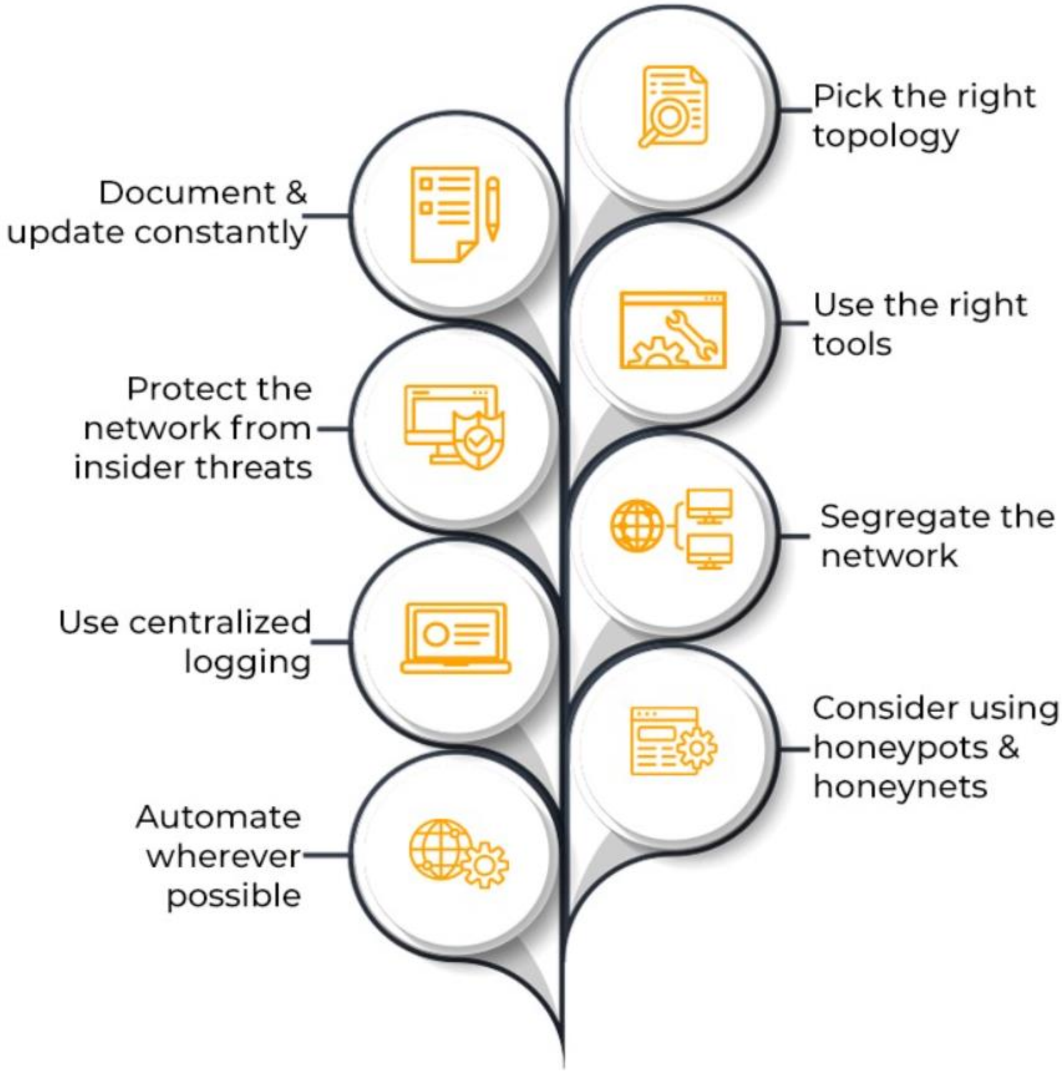


***Figure 2. 2 Processes for proper management of computer networks [35].***

1. Select the appropriate topology: The topology, or pattern, of a network refers to how its nodes are configured. Depending on the equipment and business requirements, the topology may cause the network to speed up, slow down, or even fail. Network architects must first select the appropriate network before they start [35].
2. Keep a record and update frequently: Since the network is the foundation of operations, documentation is essential. The records have to contain [35].
3. Make use of proper instruments. Network topology is the initial step in building a network that is reliable. The necessary equipment need to be placed in the appropriate locations to maintain a highly available and dependable network [35].

4. Establish the baseline network and identify any aberrant behavior. By utilizing a baseline, administrators may observe how the network normally handles traffic and user access. By placing notifications in the appropriate places, abnormalities may be promptly found after a baseline has been defined. The usual range of behavior needs to be documented at both the organizational and user levels. The baseline data can be provided by sniffers, specialized collectors, firewalls, switches, routers, and wireless APs [35].
5. Defend the network against attacks from within: Bad actors are kept out of the network by firewalls and intrusion prevention systems [35].
6. Employ centralized record-keeping: To get a comprehensive picture of the network, centralized logs are essential. Rapid log analysis can assist IT admin teams in identifying overloaded systems within the network and the security team in identifying questionable logins [35].
7. It is advisable to utilize honeypots and honey nets: honeypots are unique systems that imitate genuine processes and data, but they are actually a trap for intruders and potential dangers [35].
8. Divide the network into segments: Large and unwieldy enterprise networks are possible. Through segregation, they can be separated into zones—logical or functional units.
9. Automation should be used whenever possible: New devices are often added to systems, and obsolete ones are removed. Both the users and the access limits change often. Everything needs to be automated in order to avoid costly and dangerous security risks such as human mistake and weak zombie systems within the network [35].

## 2.6 Methods of network performance increasing

In order to ensure that the network is operating smoothly and effectively, network traffic monitoring becomes crucial [2] [6] [10].

By enhancing network performance, use a proxy server to clear the congestion on your network [3]. An endpoint device, like a computer, and another server from which a user or client is seeking a service are connected through a proxy server, which is a specialized computer or a software program operating on a computer. The proxy server first determines whether the requested page has already been viewed by the client or end-user before allowing them to access it. If so, the proxy server will serve the requested webpage; if not, the request will be forwarded to the source's location. In addition to lowering network traffic and web server load, caching can shorten the time it takes for users to access the web [3].

The goal of bandwidth management is to enhance network performance by tracking and limiting the resources allotted to each individual user or group of users [3].

A number of WAN optimization techniques, including Caching of websites, elimination of duplication, reduction in volume, and Correction of Forward Errors [5].

### 2.6.1 Reduction in volume

A WAN product's reduction in volume corresponds to the condensing of a data frame for network transport when employing a specific reduction in volume algorithm approach. Smaller data sizes will result in savings on bandwidth, space, and transfer time. This data reduction is confined to the WAN channel, and once the recipient receives the data, it immediately decompresses [5].

### 2.6.2 Caching of websites

To minimize the delivery of repetitive packets, caching is necessary if the same data or website is being viewed frequently. Delivery, since the caching server has the capacity to store frequently requested data. Therefore, web caching can aid in bandwidth conservation and enhance the effectiveness of data transmission across a wide area network. Many web servers have been using this technology to decrease internet traffic and time [5]. In addition to reducing user latency, caching can reduce network traffic and the strain on web servers [3].

### 2.6.3 Elimination of duplication

This process entails eliminating any extraneous data that must be delivered over the WAN or kept there. This not only saves storage space but also consumes less bandwidth. While file elimination of duplication is utilized to remove duplicate files, it is not considered a very efficient elimination of duplication method [6]. Maintaining a single copy of every document that is accessible to all users from across the network is part of the elimination of duplication process [7].

The techniques used for data elimination of duplication have a big influence on network performance, particularly on bandwidth usage. Numerous important benefits result from data elimination of duplication. These include improving data security, speeding up and maintaining bandwidth and storage expenses [7].

Since virtualization uses VMDK files and snapshot files to reduce data duplication, data elimination of duplication is fundamental to virtualization's transformation of data centers. Elimination of duplication lowers the need for more drives for storage, which lowers storage costs [7].

### 2.6.4 Redesigning the network's architecture

A network's performance is greatly influenced by its device configuration, network interface capacity, and network architecture. In order to improve network performance, issues with the current infrastructure's performance have been discovered, and once a suitable solution has been offered, a new network design that addresses the issues with the network and improves performance has been provided [11]. After changing the topology and reconfiguring network devices, the new design produced superior results without requiring any additional gear.

## 2.7 Network performance monitoring tools

Programs designed to monitor and manage networks comprise software that establishes connections with network elements and supplementary IT infrastructure to evaluate and document the network's topology, functioning, and overall condition [42]. Network monitoring, which is in charge of the continuous observation of computer networks, is reportedly one of the primary duties of network resource management [41]. Keeping an eye on network issues brought on by malfunctioning or overburdened servers, network connections, or other devices may assist achieve this? Through enhanced performance and reliability, network monitoring makes the network more useful [41].Three often used monitoring measures are delay, jitter or synchronization failure, and bandwidth [41].

### 2.7.1 Different types of monitoring tools

- **Nagios**: - is a tool for monitoring networks in real time [41]. Nagios's configuration's excellent scalability is one of its best features. The tool tracks not only hardware resources like memory or disk usage but also services like SMTP, PING, and HTTP.
- **Zabbix**: - This tool uses both agent-based and agentless techniques to monitor VMware, databases, applications, servers, and network hardware in addition to network services [41].
- **IBM Tivoli: -** Numerous operating systems, including Windows, Linux, and UNIX, are supported by the IBM Tivoli monitoring tool. Although it is simple to install, the analytical

and response features require the expertise of an IT specialist to configure, update, and improve [41].

- **Solar Wind**: - The excellent graphical user interface (GUI) of the Solar Wind monitoring tool is compatible with Windows, Mac, Linux, and UNIX [41]. A thorough tool for monitoring network performance that can track device status using SNMP. It is capable of automatically locating network devices that are linked to your network [43].

## 2.8 Review of Related Work

Related works are crucial for improving understanding of the research methodology technique and gaining a deeper understanding of it.

Researchers Josephine D. and R. Ab [1] have examined the CIT College Campus Network's simulation and performance analysis. They used several traffic kinds that are sent via the network between wired and wireless nodes during simulation in this investigation. For their study, the throughput and latency parameters are measured by simulating and analyzing the performance of a local area network (LAN) using the NETSIM program. During the experiment, several types of traffic are delivered over network wired and wireless nodes. The email traffic did not function properly after adjustments, and the throughput appeared to remain same. There was a minor decrease in the delay. Traffic in videos the throughput has changed reasonably, and the delay has only slightly increased. The throughput of file traffic rises, and the delay barely decreases at all.

Benfano Soewitoa, Andaya, Fergyanto E. Gunawanb, and Melki Sadekh Mansuanc [5] have studied WAN optimization to speed up data transfer for WAN networks. They used data from the simulated file transfers that were carried out over a few days and at various times for this investigation. Data was examined and quantified in terms of jitter and delay metrics using the Wireshark tool. The information movement procedure is made better efficient in the bandwidth and during the time of working hours by improving the WAN network.

A study of every network effectiveness metric is being addressed by Ruchi Tuli [2]. By employing the data packet scanning method, this data has been identified. A Wireshark tool is employed to study the data packet as well as measure a latency value.

Jon Laurence B. Wenceslao and Rhonaida B. Wenceslao have looked average efficiency based on the Out-of-the-Box, caching, filtering, and bandwidth usage situations categorized the time of obtain as well as type of websites in the proxy server [3]. A Squid Proxy tool researcher utilized.  Considering website type it included the access of the time, caching is best resulting was found blocking configuration did poor.

Abdul-Aziz Kelifa [6] has studied analyzing network performance issues to build the optimization framework. In his work, network statistics data is gathered utilizing configured network interface sensors from the traffic of the edge, core, and distribution layer of specific devices. The researcher using the Solar Winds tool the data was gathered from traffic from interfaces, top 20 interfaces by current traffic, and top 20 interfaces by CPU load. The researcher collected data and generated reports using PTRG and OPNET simulation tools. Based on predetermined parameters, the gathered data are examined, including utilization, traffic sent and received, errors and discards, availability, response time, and latency.

The researcher observed the CPU utilization from out of the 255 selected core network devices; only 11 of them used larger than 17% of their CPU capacity. This result indicates that all services of the MOR organization are executed by the very few devices. The link use of the organization MOR network has been noted by the researcher: 372 ports, or 39% of the total number of ports, are idle and 592 ports, or 61% of the total, are in use at the time the statistics were taken. This finding indicates that the interface connecting to the server farm SW3 is the one using the highest bandwidth utilization when it comes to datacenter connections.

Ribiro N. S. [7] has investigated the parameter packets sent within a particular time and the number of packets received within the same period compared between the optimized and non-optimized networks in the simulated WAN network. All VLANs and all ports were used to collect data for the measurements, which were conducted between WAN networks. The number of packets received by a specific node.

The data were collected and recorded during a 30-second period for both the optimized and non-optimized networks. The researcher has observed that improved networks receive more data in a given period of time. This time, there is more data roughly 60 kb. Large amounts of data being sent and received suggest that, with proper optimization, a wide range of tasks can be completed across the WAN. This demonstrates the excellent performance and efficiency.

Obunadike Georgina N.1 and Tyokyaa K. Richard [9] have investigated optimum performance by optimizing computer networks. By using the OPNET tool, create a network model, then collect statistics in order to evaluate the network's performance.

To determine the network's overall delay, the researcher employed global statistics to collect data about the entire system. The statistics used centralized network 2, centralized network VPN, and centralized network gpz2 to evaluate the global network latency. The virtual private network connection has the least amount of global network latency. The delays range in duration from 0.00006 to 0.000150 seconds. This, in terms of the globally recognized criteria for network latency, is acceptable. As the VPN connection yields the best result, it is optimal. The result falls roughly between 0.00006 and 000075 seconds.

Tsegaye [10] this study uses a performance analysis tool to examine the effects of various WAN variables. The Network Performance Monitor (NPM) tool is used in his investigation to gather traffic data from the AAU WAN environment. After the data has been analyzed and evaluated, measures such as packet loss, response time, and network availability are used to look at the performance of the network. Lastly, a WAN optimization framework is constructed using the analysis's results.

Munam Ali Shah [11], the researcher, has studied to improve the network performance. A case study of a campus network that is in use has been taken into consideration. Gather statistics data and examine specific network performance with the help of the OPNET tool. Numerous design issues have been identified based on the network of statistical data that is now available. The actual bus topology of the building's computer network was also noted by the researcher. There were traffic bottlenecks, periodic updates, delayed convergence, no firewall configuration, and no access policies as a result of the incorrect RIP routing protocol selection. After cascading was eliminated, direct Ethernet connectivity between each level and the block server room allowed for optimization. Throughput has increased while the WLAN load has been reduced.

Setiyo Budiyanto [12] he was studied measure network status consume the flow of data in the network evaluate the efficiency of digital educated services. He employed a Peer Connection Queue technique to control the traffic for Quality Services. The parameters of this study including throughput, delay.

Dr. Amin Babik and Randa Ibrahim Mohammed [13] have researched optimizing solutions for network connections with a restricted bandwidth. Using a graphical packet analyzer, collect network traffic pattern information to detect errors, wasteful instances.

## 2.9 Research gap

Upon analyzing the current network infrastructure and conducting relevant empirical research, the investigator identified various issues affecting network performance. These include sluggish network speeds, frequent network downtime, insufficient bandwidth, ineffective resource allocation, and vulnerabilities in security.

***Table 2. 1 Network performance measurement techniques and tools.***

| Ref | Author | year | Method | Result |
|---|---|---|---|---|
| [1] | D. Josephine.D and R. Ab | 2020 | NetSim's GUI run simulation | Results of three traffic type based on throughput and delay metrics<br>Email traffic there was no change in the throughput. A minor reduction in the **delay**—**0.079** milliseconds for **wired** nodes to **wired** nodes, **1.39** milliseconds for wireless nodes to wireless nodes.<br>Video change in throughput for this data flow is in the range of 100Kbytes but very minor increase delay.<br>FTP throughput increase to around 40Kbytes and the slightly decreased by **0.107**msec. |
| [5] | Benfano Soewitoa, Andya, Fergyanto E. Gunawanb, Melki | 2017 | Wireshark tool (delay, jitter )and Tera Copy tools 11(measuring | Delay become well from **287** MS to **0.604** MS for file size 93 MB and jitter increased **12.4%** better. |

| | | | | |
|---|---|---|---|---|
| | Sadekh Mansuanc | | throughpu t | |
| [2] | Ruchi Tuli | 2023 | Wireshark tool | Wireshark Shown time of capturing the packet, Source & destination IP, protocol name, and length of the packet (in bytes), captured and dropped is also shown. |
| [3] | Jon Laurence B Wenceslao1 , Rhonaida B Wenceslao | 2022 | Linux 19.10 the Google Timer Interface Squid Proxy version 3.4. | The performance of proxy-enabled during Am session<br>Show that OOTB was **81.7505s**; caching was **59.1614s**; filtering was **71.9893s** and bandwidth allocation was 71.5694s.the result show that there is positive improvement.<br>Three configurations yielded better performance than the OOTB with the caching configuration having the best improvement.<br>In **the P.M.** sessions, the average network performance showed that with OOTB was 77.5774s; caching was 72.8317s; filtering was 136.6944s and bandwidth allocation was 71.4066s. The result noted that **the caching** and **bandwidth allocations** resulted in positive improvements since the average performance from these configurations were all lower as compared to that of the OOTB configuration. However in the filtering configuration, there was a decrease of **56.72%** in the performance with reference to the OOTB result. |

| | | | | |
|---|---|---|---|---|
| | | | | **Type of website is stati**c, the OOTB, as the benchmark, was able to finish content loading the content at **7.2972s** .When the proxy server was configured by caching, its average score was **4.2972s**; filtering was 4.8648s while bandwidth allocation was at **6.9231s.**<br>Positive improvements in all configurations are compared to the OOTB. Three configurations indeed generated better performance than the OOTB.<br>**For dynamic webpages** the network performance of the OOTB configuration was **151.792s**. When the proxy server was configured to **caching**, the network performance was **127.2343s;** for filtering, it was computed at **202.875s** while bandwidth allocation, the network performance was produced **136.0553s.** These results showed that there were **positive improvements** in the network performance when the configurations were **caching** and **bandwidth** allocation .On the other hand, when the configuration was filtering, the network performance became slow. |

| | | | | |
|---|---|---|---|---|
| [6] | Abdulaziz Kelifa | 2021 | Solar winds tool PTRG tool, OPNET simulating tool | By PTRG tool report the branch office showed that the average network availability of 131 segment 51% down and 49% up.<br>Response time: - the response time measured from 231 active device and 48 device measured zero in both average and peak response time. That means they are inactive.<br>24 devices response time not available. The average Response Time is 0.35msc and the Peak Response Time is 115.8msc. |
| [7] | Ribiro N. S | 2014 | simulated in GNS 3 software | There is a large number of data packets dropped in the case of a non-optimized network.<br>The data sent and receive is high when optimized WAN compare to non- optimized one. |
| [9] | Obunadike Georgina N.1 and Tyokyaa K.Richard2 | 2015 | OPNET tool IT GURU virtual network | The delays are between 0.00006 and 0.000150 seconds long. Which is Ok according to the internationally accepted bench mark for network delay.<br>VPN connection best of three connection. |
| [10] | Tsegaye Birhanu | 2014 | Solar winds Network performance tool**.** Data is collected on the researcher's machine | The highest response time is recorded 184.94 ms in one of the starting of the working days and at this time a maximum of 72% of packet is lost**.**<br>On average, a maximum of 67% and a minimum of 18% of data is lost during the 30 days of time interval. The reason for this packet lost is link failure. |

| | | | | |
|---|---|---|---|---|
| | | | Using a web console techniques | |
| [11] | Munam Ali Shah | 2011 | OPNET | Simulation-based routing protocol performances have been analyzed by which revealed efficiency of EIGRP over RIP which uses single routing metric and exchanges periodic copies of entire routing table which makes the RIP network congested. |
| [12] | Setiyo Budiyanto | 2021 | PCQ (Peer Connection Queue). Using the traceroute command. QoS measurements Wireshark | The result of this application obtained a user satisfaction rate of 59.2%.<br>Average delay 10 test captured<br>delay result of 79 Ms.<br>according to ITU-T standard, the excellent delay category is the delay value < 150ms<br>$Troughput = Number\ of\ Data\ Sent\ Data\ Delivery\ Time$ = 47,690 174,012 = 27,40 $bytes$/s<br>According to the medium throughput value that is between 25- 50 Bytes / s by looking at the reference of TIPHON standardization. The network is well.<br>Packet loss With the result of packet loss calculation sought is 0%. Therefore, referring to itu-T standardization<br>The network works very well because none of the packages are lost when sending data. |
| [13] | Randa Ibrahim | 2015 | VB soft ware Analysis graphical packet analyzer | output<br>Incoming 208.053kpbs recorded 274.906kbps<br>Outgoing 4.837kbps recorded 10.312kbps. |

# CHAPTER THREE

# 3 RESEARCH METHODOLOGY

## 3.1 Introduction

An overview of the population, sample frame, sampling procedure, research design, methods, and instruments utilized in the research process, and data collecting tools is given in this chapter.

## 3.2 Research design

In this research, the investigator employed the Design Science methodology. The sequence of the design science process is as follows:

**Recognized Difficulty:** Conduct a comprehensive analysis of the network infrastructure within the Addis Ababa Public Services and Human Resource Bureau to pinpoint specific obstacles and shortcomings that are impacting overall performance.

**Framework development:** Constructing a framework for enhancing network performance optimization specific to the bureau's requirements involves addressing the identified issues alongside an in-depth exploration of pertinent literature and industry best practices.

**Constructing Artifacts:** Transform the theoretical framework into a physical artifact, like series of recommendations, approaches, or resources, created to aid in enhancing network performance within the organization**.**

**Evaluation:** Implement the suggested framework in the network infrastructure of the Addis Ababa Public Services and Human Resource Bureau for artifact evaluation. Assess the efficiency and user-friendliness of the artifact to enhance network performance by assessing quantitative metrics such as network speed, latency, and throughput, along with collecting qualitative feedback from stakeholders

**Contemplation and Repetition**: During the process of artifact evaluation, take time to reflect on the findings and pinpoint areas within the framework that could benefit from enhancements. Continuously fine-tune the artifact by incorporating feedback and insights gathered throughout the implementation phase.

## 3.3 Research method

The methods of research involve the particular techniques utilized to gather and evaluate data. Here are basically three distinct types of study practices: hybrid, qualitative, and quantifiable. The method that is qualitative will be expressed via words, and the statistical method will be represented through statistics. Gathering information through conversation is a means for conducting qualitative investigation. The responses which have been gathered are basically not numerical. Focus groups, in-person discoveries, and the interviewing represent a few of the techniques employed for the collection and interpretation of qualitative information.

Methods that are quantitative address data that has numerical and tangible forms and apply a systematic approach for handling information.

This investigation incorporated qualitative as well as quantitative study methods. In this research, information has been collected via observations, inquiries, conversations, and other techniques.

## 3.4 Population Size and Sampling

### 3.4.1 Target Population

In research, there is a relationship between the terms population and sample. A sample represents a subset of the population that has been chosen, whereas the population itself is the entire collection of items.

As a result of the researcher's conviction that they can understand the questions on the questionnaire, the entire population was taken into account for this study.

In this work, the population of the research is the ICT experts who use the public service and human resource bureau network. In this research the total number of the population was 30.

### 3.4.2 Sampling frame

A frame of sampling includes a list containing every item within the population. In the frame of sampling the sample will be collected depending on specifying sampling units. This implies that while determining a sample number, a researcher should set the criteria for inclusion and exclusion. The ICT professionals who used the public service and human resource bureau network are the study's focal demographic. Target population separated into four sample frames: ICT employees in public service and human resources, TVT bureau employees, youth and sports bureau employees, and innovation bureau personnel. This is the sample frame used in our research. This sample frame is where the sample was chosen from. The sample frame of the intended population is shown in the following Table.

*Table 3. 1 sampling frame of in this the research*

| No | sample frame | Total population according to sample frame |
|---|---|---|
| 1 | Public service & human resource bureau ICT staff | 10 |
| 2 | TVT bureau ICT staff | 10 |
| 3 | Youth & sport bureau ICT staff | 10 |
| 4 | Innovation bureau ICT staff | 20 |

### 3.4.3 Sampling Technique

To put a sampling method into practice, many sample techniques must be used. Prior to describing a section of the targeted population that the investigator can utilize to ensure a sample frame, ascertain the intended population. After that, before choosing a probability or non-probability sampling approach, an investigator should decide what inclusion and exclusion criteria apply to the sample unit. Pick the sample's size at the end.

Using the Public Services and Human Resource Bureau's ICT experts, a TVT bureau, the Youth and Sport Bureau, and the ICT staff's Innovation and Technology Bureau as examples of our target demographic. In this research we used a non-probability and purposeful sampling technique.

According to P. T. D. M. Masrom [20], our sampling size was calculated in the manner described below.

$$n = \frac{N}{1 + Ne^2}$$

Where: n = the sample size

N= the population of the study (30)

e= the level of significance (set at 0.05 for this study)

To get the sample size, use the formula

$$n = \frac{30}{1 + 30*(0.05)^2}$$

$$n = 28$$

Out of the total population 28 sample was consider in this work.

***Table 3. 2 Participants in the Questionnaire***

| NO | Target Groups | Position | Quantity |
|---|---|---|---|
| 1 | Public Service ICT Directorate | ICT Director | 1 |
| | | ICT experts | 3 |
| 2 | Youth& Sport ICT Directorate | ICT Director | 1 |
| | | ICT experts | 3 |
| 3 | TVT ICT Directorate | ICT Director | 1 |
| | | ICT experts | 2 |
| 4 | Innovation Technology Bureau operation Directorate | Information Technology Operation Director | 1 |
| | | Information Technology Team leader | 2 |
| | | Network Administrator | 4 |
| | | ICT Expert | 1 |
| 5 | Innovation Technology Bureau Datacenter Directorate | Datacenter Director | 1 |
| 6 | Innovation Technology Bureau Infrastructure Design and Development Directorate | Infrastructure Design and Development Director | 1 |
| | | Infrastructure Development Team leader | 1 |
| | | Network engineer | 6 |
| TOTAL | | | 28 |

Different ICT experts, including ICT directors and experts from various government bureaus such as Public Service, Youth & Sport, and TVT, as well as roles like Information Technology Operation Director, Team Leader, Network Administrator, Datacenter Director, and Infrastructure Design and Development Director, were consulted along with Network engineers from the Innovation & Technology bureau.

## 3.5 Methods and tools of Data collection method

Data collecting methods refer to the many procedures used to gather data. We need certain tools in order to gather and measure the data. A tool is a measurement, data collection, and analysis tool.

### 3.5.1 Methods of data collection

Primary as well as secondary sources of data constitute a possibility from which to gather information. Our capture the initial data via inquiries and observations as a way to address our research topic, making is the main source of data. Second-hand data pertains to knowledge which has been previously utilized. In this study, the techniques used to acquire information are discussed.

#### 3.5.1.1 Interview

Interview was conducted with 3 persons the ICT director of the public service &human resource bureau and innovation bureau ICT team leaders through the open ended questions which is designed to about the problems of network performance of the organization. The interview is primary type’s data source and its qualitative type of research method.

#### 3.5.1.2 Questionnaire

Questions come in two types: open and closed. Closed inquiries were used by the investigator in this work. Using a scale made up of five Likert points that encompasses "Strongly do not agree" = 1 up "Highly Agreed" = 5, then the investigator will administer it.

Questioner the primary form of information sources as well as a quantifiable form of research strategy. Employing a Google form questioner approach for gathering information regarding the people who responded that are ICT specialists of the company, by supplying the questioner's email address. One advantage of using Google Forms is that you can collect data more efficiently in terms of money, time, resources, and respondent availability.

This survey is in two portions. The respondent's basic information, including their sex, educational background, and position, is provided in the first part. We also talk about the respondents' professional backgrounds.

The second section contains 25 questions that are divided into three categories. The first is general information about the network performance status. The second one is the problem of the network performance of the organization's network. The third one is the improvement techniques to optimize the network (see Appendix). A total of 28 research questionnaires were distributed by email, and 24 (88.9%) respondents returned them.

#### 3.5.1.3 Observation

Since observation allows for data collection without participant interaction, it is a popular strategy for gathering information about study subjects. The researcher looks into the organization network's current network infrastructure. It is the main technique for obtaining data. In order to learn about field observation of the network device in the organization's network environment, the researcher documented observation. We refer to it as a secondary data source.

#### 3.5.1.4 By using the Wireshark tool

The network interface provides the source of the data. As stated in [2], Ruchi Tuli a packet passes across a number of intermediary devices on its way from its source to its destination. The physical address of a NIC is what gives each device on the network its own unique identity. All the devices in the network receive the data when a device transmits a packet. All data transmitted over a network will be received by any node having a promiscuous mode-configured NIC. In promiscuous mode on the NIC, the computer may see all traffic on the segment. In contrast, the NIC records and gathers all network frames and packets when it is set up to be promiscuous for a single machine.

## 3.6 Data Analysis Method

In this work the data analysis is done in two methods.

### 3.6.1 Using the Wireshark tool

We preserve the information collected to offline examination and evaluate the current online activity that has been collected. A collected packet is able to be viewed in the statistics section of the menu by clicking on the captured files properties choice. These provides information about the interface's kind, dropped file which include the measurement data of the packet including its duration for the capture operation. The Wireshark program is employed for examining and evaluating how the network operates using various metrics following data capture.

Wireshark A packet analysis tool that is a software application which can detect and record information that goes across an internet and then provide collected packet data in as much detail as possible.

### 3.6.2 Using the Google Form

Data is gathered from the targeted ICT expert using the online Google Form Questioner technique. The data is then analyzed using the Google Form tool.

## 3.7 Proposing Network Performance Optimizing Framework

The primary goal of this effort is to provide the institution with a framework for network performance improvement. The framework that was built was based on the findings of the network performance analysis from the Ethernet interface of traffic, the interview, and the conduct of the questioner from the user replies who were ICT specialists. The validation of the framework done In addition to the respondent of ten senior ICT experts the validation process has been done implement framework have confirmed the suggested methodology for optimizing network performance.

## 3.8 Tools used in research processes

Certain devices or methods that the researcher employs to gather and process data are called research tools. Another definition of a tool are computer applications that are useful for designing.

In this work, we have used the following tools for the purpose of the research process:

- Google Forms tool for data collection and analysis.
- The Wireshark-win64-4.0.6 version tool has been used for the data collection of network traffic from the network device Ethernet interface and the analysis of the data.
- Packet tracer version 6.3 tool for the purpose of drawing the existing network infrastructure of the public service and human resources bureau.
- Edraw-max-5557 version tool for the purpose of drawing a network performance optimization framework.

## 3.9 Organization network Infrastructure understanding

The public service and human resources bureau in Addis Ababa is connected to the internet via two different types of connections: a 200 MB/s internet fiber connection and an Ethernet connection with a 50 MB/s wordanet VPN. The currently available total number of ports in the organization is 700, however the number of ports doesn't seem enough relative with the overall number of users that have already utilized the network.

The existing network interconnection in the public service and human resources bureaus is shown in figure 3.1

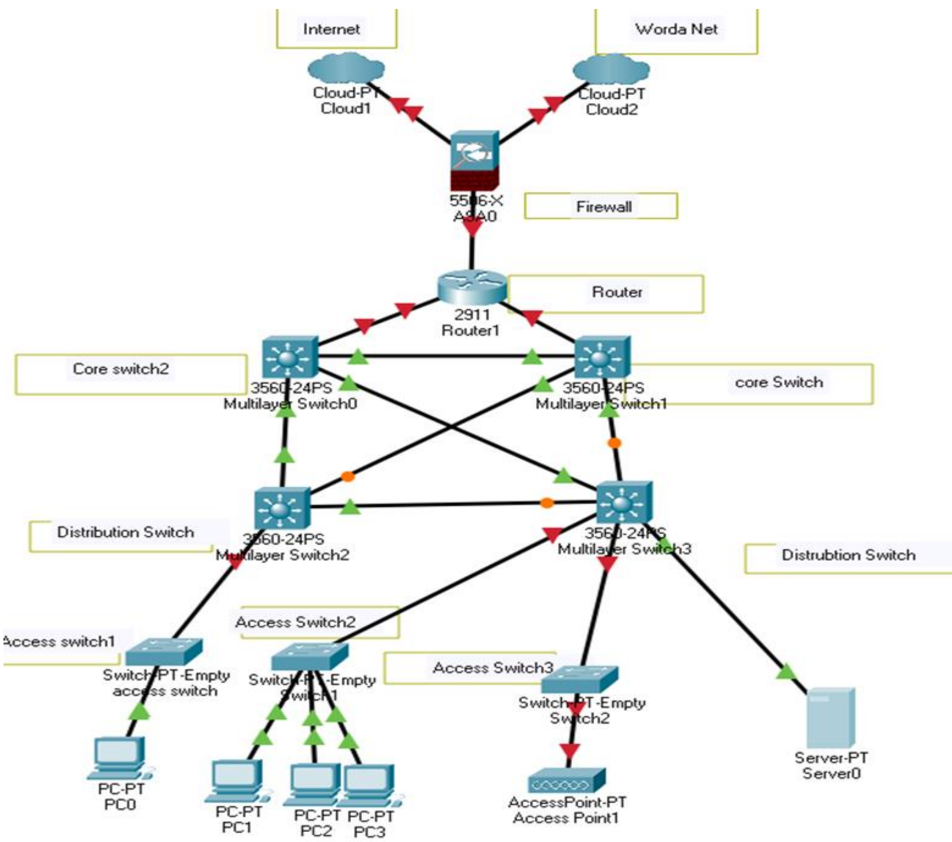


***Figure 3. 1 Addis Ababa Public services and human resource bureau Network architecture***

## 3.10 Instruments for measuring network performance

In this work, the researcher used the Wireshark tool to measure the network performances. The Wireshark tool is installed on the researcher's computer, and then the network interface is selected to capture the traffic packets.

After the packets are captured by using different statistical tools, we measure the network performance problems. In Wireshark, by using the statistic menu and observing endpoint windows to detect the top bandwidth user utilization and input and output graphs, we will look at the basic status of the connection.

# CHAPTER FOUR

# 4 RESULT AND DISCUSSTION

## 4.1 Introduction

At this part, a researcher presents the findings from the assessment for network efficiency which was collected from the Ethernet interface about the network's activities, the interview conducted, as well as the information collected from the survey which was conducted by a focus group of ICT experts, ICT team leaders, as well ICT directors about the network's general bottlenecks as well as the improvement solution.

## 4.2 Network traffic analysis using Wireshark

The Wireshark application was used to analyze network traffic in the public services and human resources bureau's Addis Ababa network settings.

In order to obtain the data for real-time monitoring, the capture filter shrinks the size of the incoming packets. We can quickly identify the packets based on their color of the collected packets. Erroneous packets are shown by the colors black and red, TCP packets by the light purple color, and UDP traffic by the light blue color [19] [25].

Using statistical tools and measurements, I examined a variety of network traffic in my work. I measured and examined parameters including throughput, latency, response time, lost packets, over-band, average bandwidth usage, and round trip time (RRT) using the Wireshark tool.

### 4.2.1 Utilization of Bandwidth

When we refer to "network bandwidth utilization," we indicate that the fastest possible data transfer rate over their network can be found there. Overuse of bandwidth is one of the causes of poor network performance and difficulty in using it.

In this work, the researcher detected over-bandwidth utilization of the endpoints; using the Wireshark tool in the endpoint window's statistic tool, we found the endpoints with the highest bandwidth consumption. Click on endpoints from the statistic menu, choose the IPV4 tab, then arrange the endpoints' IP addresses according to TX Bytes (Transmit). The endpoint in the top row is the one using the most bandwidth after sorting by transferred bytes. The results displayed in Figure 4.1 below.

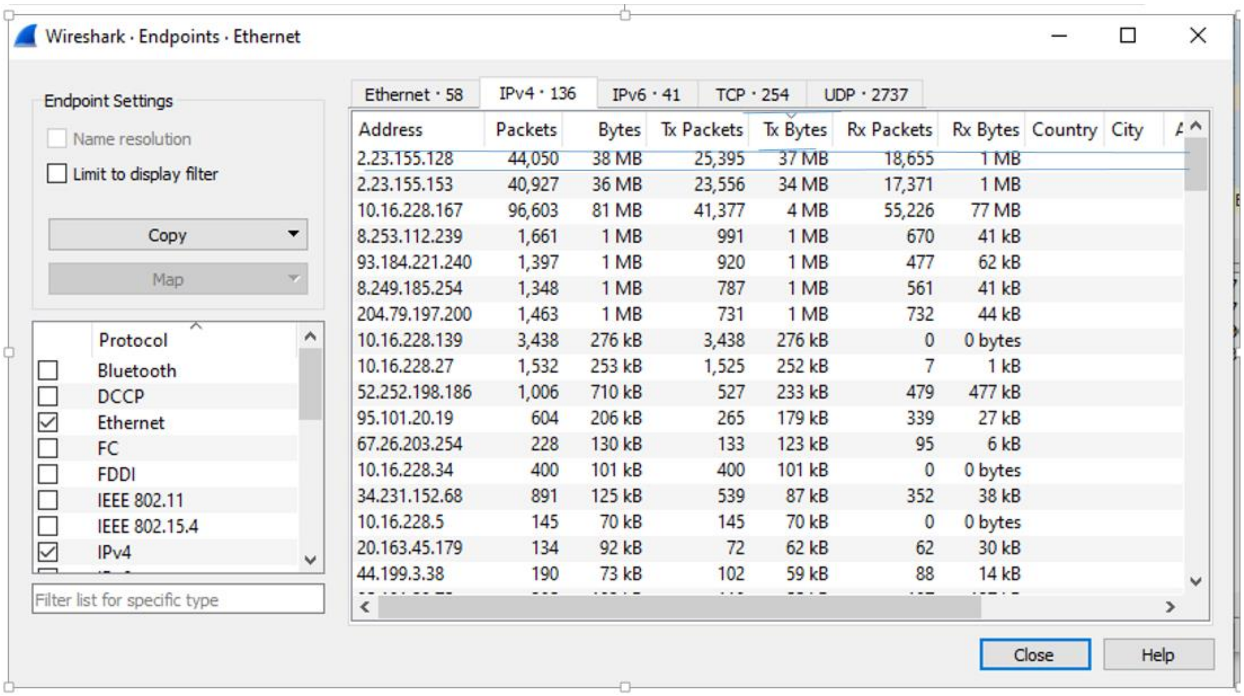


***Figure 4. 1 lists the top endpoints for bandwidth usage.***

If the IP addresses in the above figure are unfamiliar to us, you should activate name resolution. As seen in Fig. 4.2, choose Preferences from the Edit menu.  As shown below.

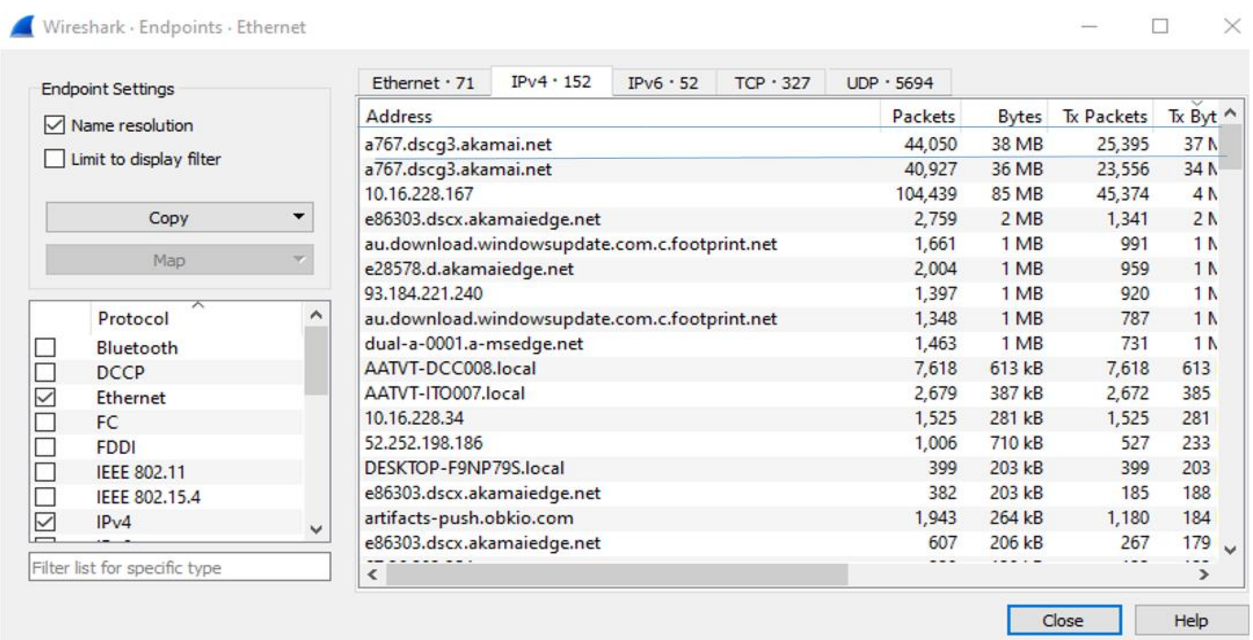


***Figure 4. 2 The resolution-named endpoints' greatest bandwidth utilization.***

***Table 4. 1 displays the IP addresses of the endpoints with the highest bandwidth usage***

| No | IP addresses | TX(transmit )bytes |
|---|---|---|
| 1 | 2.23.155.128 | 37 MB |
| 2 | 2.23.155.153 | 34 MB |
| 3 | 10.16.228.167 | 4MB |
| 4 | 8.253.112.239 | 1MB |
| 5 | 93.184.221.240 | 1MB |
| 6 | 8.249.185.254 | 1MB |
| 7 | 204.79.197.200 | 1MB |
| 8 | 10.16.228.139 | 276KB |
| 9 | 10.16.228.27 | 252KB |
| 10 | 52.252.198.186 | 233KB |
| 11 | 95.101.20.19 | 179KB |

***Table 4. 2 reveals the name resolution address of the endpoints with the highest bandwidth usage.***

| No | Resolution Name | TX(transmit )bytes |
|---|---|---|
| 1 | A767.dscg3.akamai.net | 37 MB |
| 2 | A767.dscg3.akamai.net | 34 MB |
| 3 | 10.16.228.167 | 4MB |
| 4 | E86303.dscx.akamaiedge.net | 2MB |
| 5 | Au.download.windowsupdate.com.c.footprint.com | 1MB |
| 6 | E28578.d. akamaiedge.net | 1MB |
| 7 | 93.184.221.240 | 1MB |
| 8 | Au.download.windowsupdate.com.c.footprint.com | 1MB |
| 9 | dual-a-001.a-msedge.net | 1MB |
| 10 | AATVT-DCC008.local | 613KB |
| 11 | AATVT-Ito007.local | 385KB |

TX bytes are the end point's largest bandwidth demand, according to the results based on IPV4 filters. The name resolution is A767.dscg3.akamai.net, and the IP addresses are 2.23.155.128. 37 megabits of bandwidth are now in use. The endpoint's lowest bandwidth use from the 11 addresses that were chosen and are included in the table of IP addresses 95.101.20.19 is 179 KB, whereas AATVT-Ito007.local is 385 KB.

Some IP addresses, like 10.16.228.167, are not converted into domain names. This is because we are trying to record the packets before the connection is formed, but we are either not recording the DNS resolution packets or we are missing part of the DNS packets. Therefore, the Wireshark IP address cannot be used to translate the domain name.

Using the Wireshark application, which is displayed within the protocol's hierarchy's windows, a researcher examined the bandwidth consumption of each protocol in the capture file. The result is shown in figures 4.3.

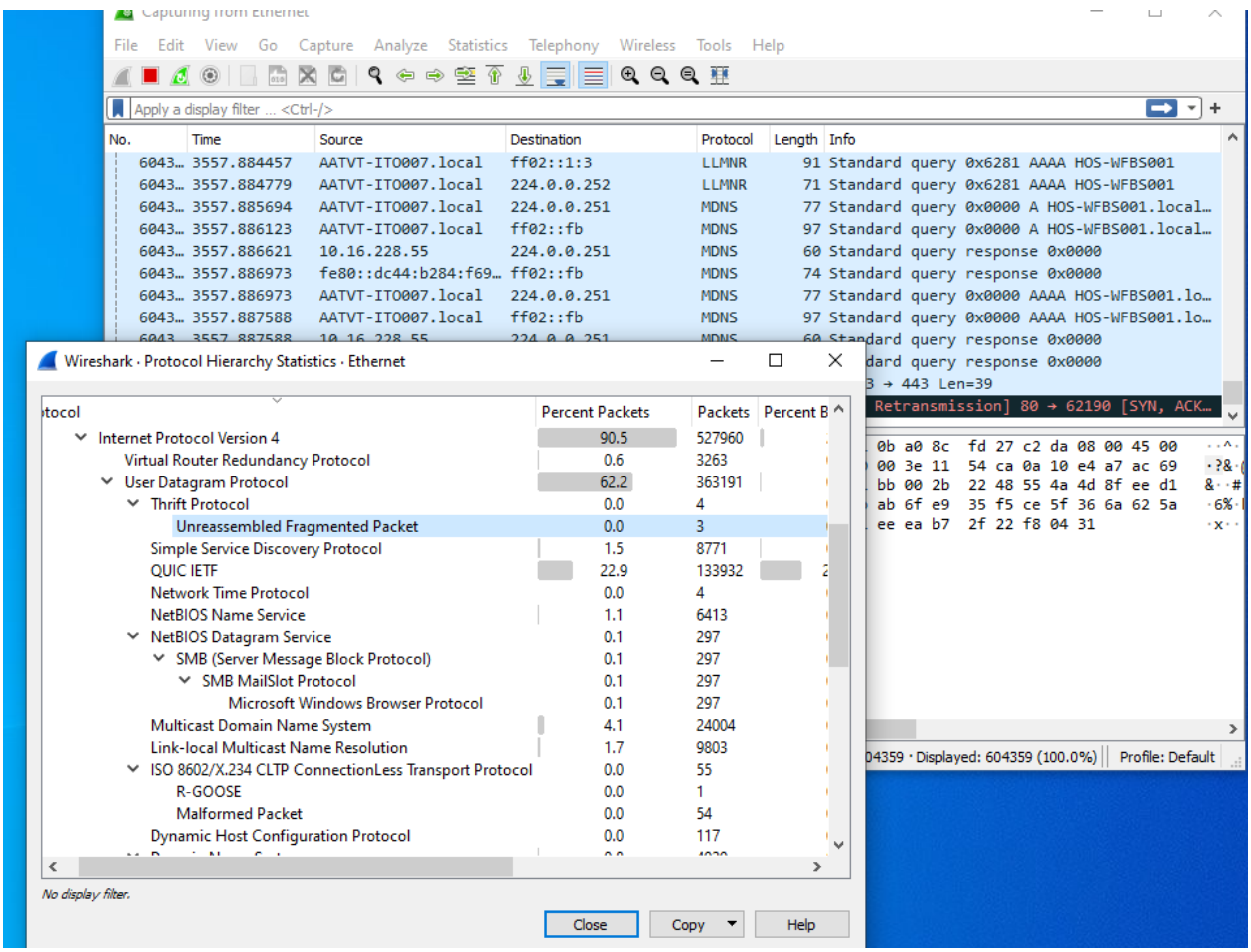

***Figure 4.3 the bandwidth usage of each protocol was examined using the protocol hierarchy window.***

The graph that comes with it displays the protocol dispersal found within the gathered files. In this study, the worldwide internet protocols fourth version (IPV4) disseminated 90.5% of the total number of packets of data, whereas the user a datagram procedure (62.2%) utilized a percentage of the data packets.

***Table 4. 3 reveals protocol hierarchy window protocol distribution capture data***

| No | Protocol Name | percent of packets | The number of packets |
|---|---|---|---|
| 1 | Internet protocol version 4(IPV4) | 90.5 | 527960 |
| 2 | User datagram protocol | 62.2 | 363191 |
| 3 | Simple service discovery protocol | 1.5 | 8771 |

This column shows a percentage of protocols packet compared to every packet included in the capture.

Packet: - This column represents the entire amount of packets using this type of protocol. The Internet Protocol (IP) version four (IPV4) exhibits the highest dispersal percentage for this study 90.5% among every one of the packets in the capture. The following user datagram protocol is 62.2%.

### 4.2.2 Drops of packets

Using the Expert Information button, we examine in our study the way data loss or drops occur and the way packets get moved throughout the internet form their origin to the target address. Loss of packets represents one of the factors that deteriorates network performance.

In this paper, we observed packet loss or drop via network flow. Using the Wireshark tool, the researcher examined packet loss in the expert information tool. We looked at DNS response retransmission, damaged packets, and response not found. Retransmission is the process of sending a request or response more than once; it happens when a packet is lost.

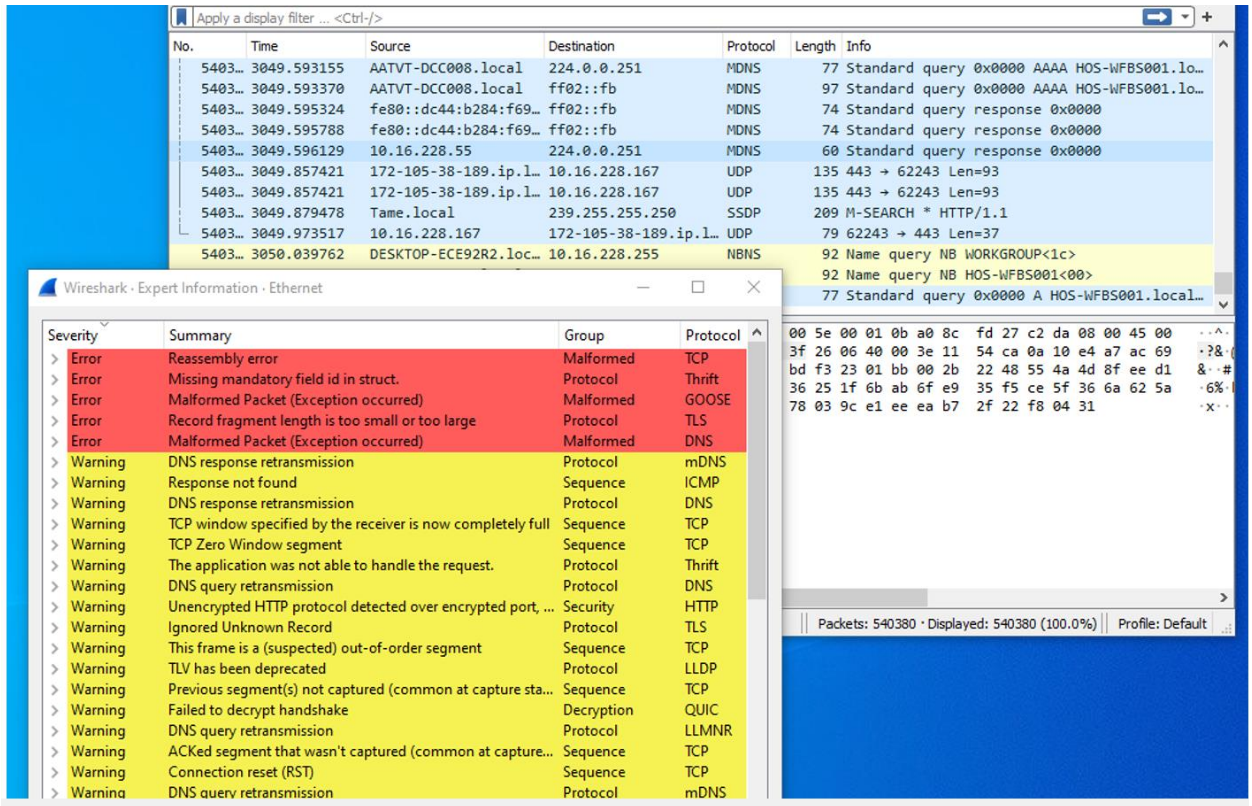


***Figure 4. 4 indicates packet drop***

### 4.2.3 TCP stream utilizing a graph of throughput

In this study, we have observed instability in the throughput graph, which fluctuates in value while examining the higher throughput of 660,000 bits/s, 420,000 bits/s, and 180,000 bits/s, the smaller throughput of 40,000 bits/s, and 20,000 bits/s, using the Wireshark tool and the TCP stream graph.

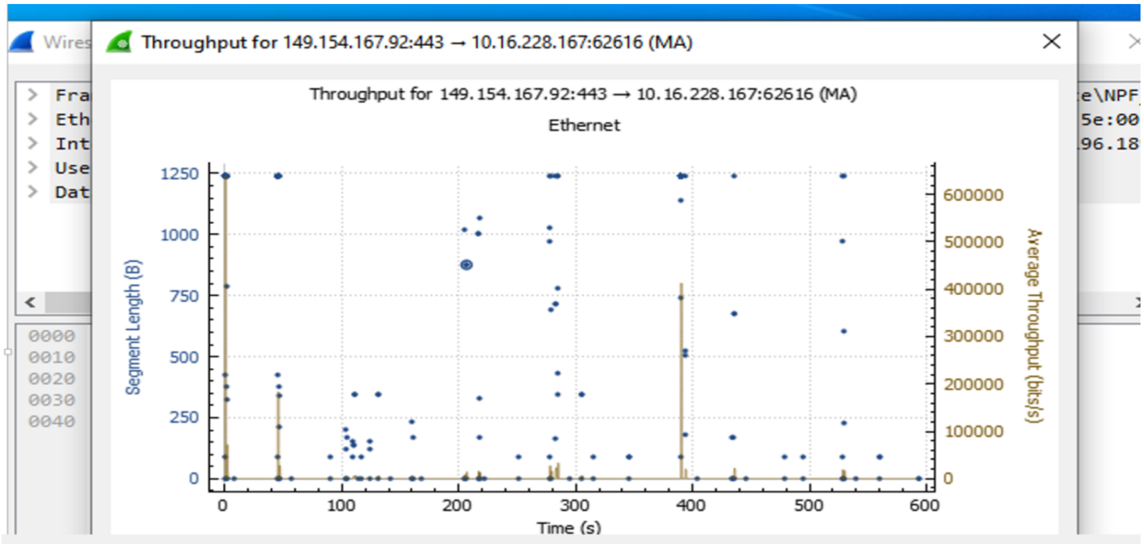


***Figure 4. 5 shows throughput value using TCP stream.***

### 4.2.4 Round Trip Time (RTT) graph with TCP stream

The whole amount of trips a request passes via an internet connection when a response has been received is designated at the total amount of trips (RTT). RTT as usually calculable using millisecond. A lowered RTT as a yields more responsiveness.

An acknowledgment is received after a packet is transmitted, and this duration is known as the total amount of trips (RTT). In other words, in order to get an ACK indicating if the packet was delivered correctly, each request transmitted by a host requires TCP communication. The round-trip duration denotes the entire period of duration which goes by between the sending of the packet, and it being acknowledged (ACK).

The y-axis, on the other hand, represents the response time (RTT) in milliseconds, whereas the horizontal x axis represents the Transmission Control Protocol (TCP) sequences number. Every highlighted spot in the graph indicates the packet's response time the RTT. Lower latency has been correlated to fast reaction durations; latency that is elevated is associated to prolonged information transfers over networks. We have utilized the total amount of trips (RTT) statistic in our research to evaluate latency in networks. Utilizing a TCP streams graph with a Wireshark tool, we examined an RRT graphs. Fig. 4.6 depicts a network's latency assessment using an RTT graph.

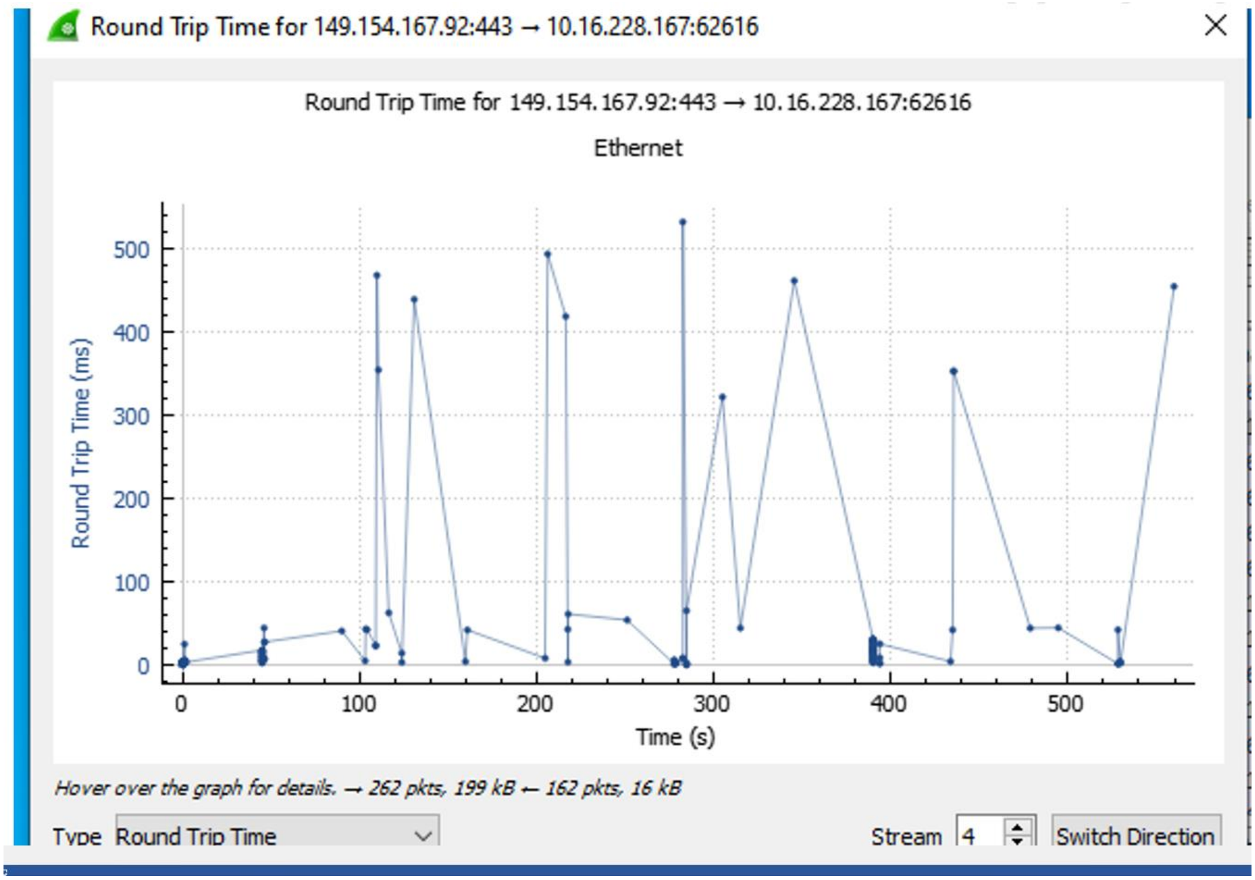


*Figure 4. 6 RTT graph to measure latency*

*Table 4. 4 measurement of RTT graph result*

| NO | Round Trip Time(MS) | Sequence number | Status of performance |
|---|---|---|---|
| 1 | 40 MS | 40 s | Optimal(RTT<100ms) |
| 2 | 20 MS | 110s | optimal(RTT<100ms) |
| 3 | 340 MS | 110s | performance degraded(RTT>=200) |
| 4 | 480 MS | 110s | a connection being terminated(RTT>375) |
| 5 | 60 MS | 115s | optimal(RTT<100ms) |
| 6 | 460 MS | 120s | a connection being terminated(RTT>375) |

| NO | Round Trip Time(MS) | Sequence number | Status of performance |
|---|---|---|---|
| 7 | 30 MS | 160s | optimal(RTT<100ms) |
| 8 | 500 MS | 200s | a connection being terminated(RTT>375) |
| 9 | 420ms | 220s | a connection being terminated(RTT>375) |
| 10 | 540ms | 280s | a connection being terminated(RTT>375) |
| 11 | 320ms | 300s | performance degraded(RTT>=200) |
| 12 | 440ms | 340s | a connection being terminated(RTT>375) |
| 14 | 340ms | 430s | performance degraded(RTT>=200) |
| 15 | 460ms | 530s | a connection being terminated(RTT>375) |

When the RTT is less than 100 MS, it functions at its finest.

The RTT of 100–200 MS most likely had an effect on performance.

The RTT 200ms performance deteriorated.

A connection is frequently lost when an RTT is higher than 375 milliseconds. An examination of a broken connection and a decrease in performance were shown by the RTT graph measurement. This suggests that the network delay detects and remains unresponsive upon connection termination.

### 4.2.5 By using I/O graph to measure network problem

In this study, the Wireshark program was used to view the I/O graph from the Statistics menu. The TCP error has been observed in the figure 4.7 below.

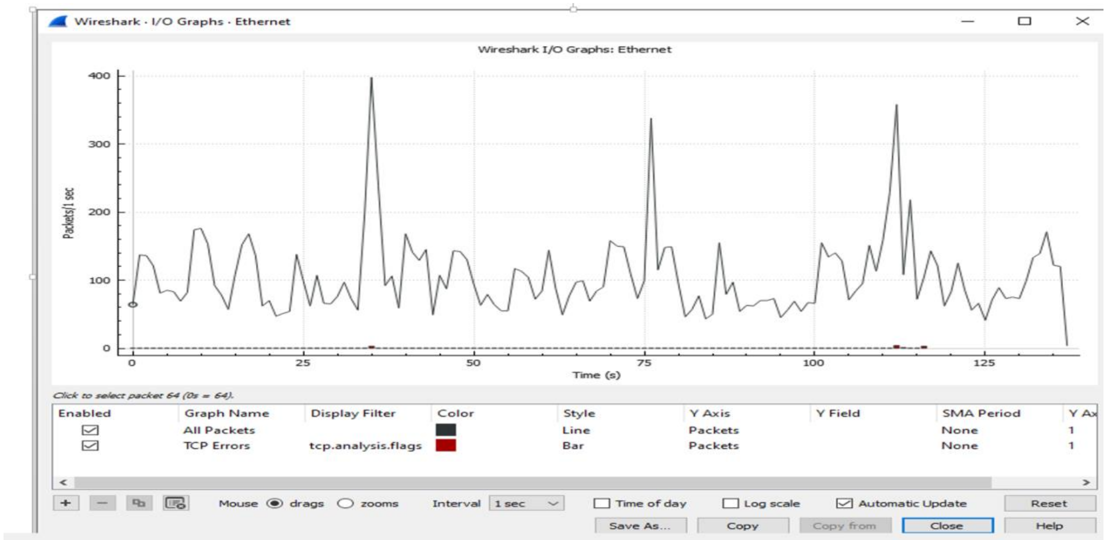


***Figure 4. 7 by investigating TCP error with an I/O graph***

TCP error is shown by the red color in Figure 4. 7's bar graph. At 35 seconds and packet value 0, as well as between 110 and 120 seconds with packet value 0, a TCP error was observed. The line graph shows the packet flow of all network traffic.

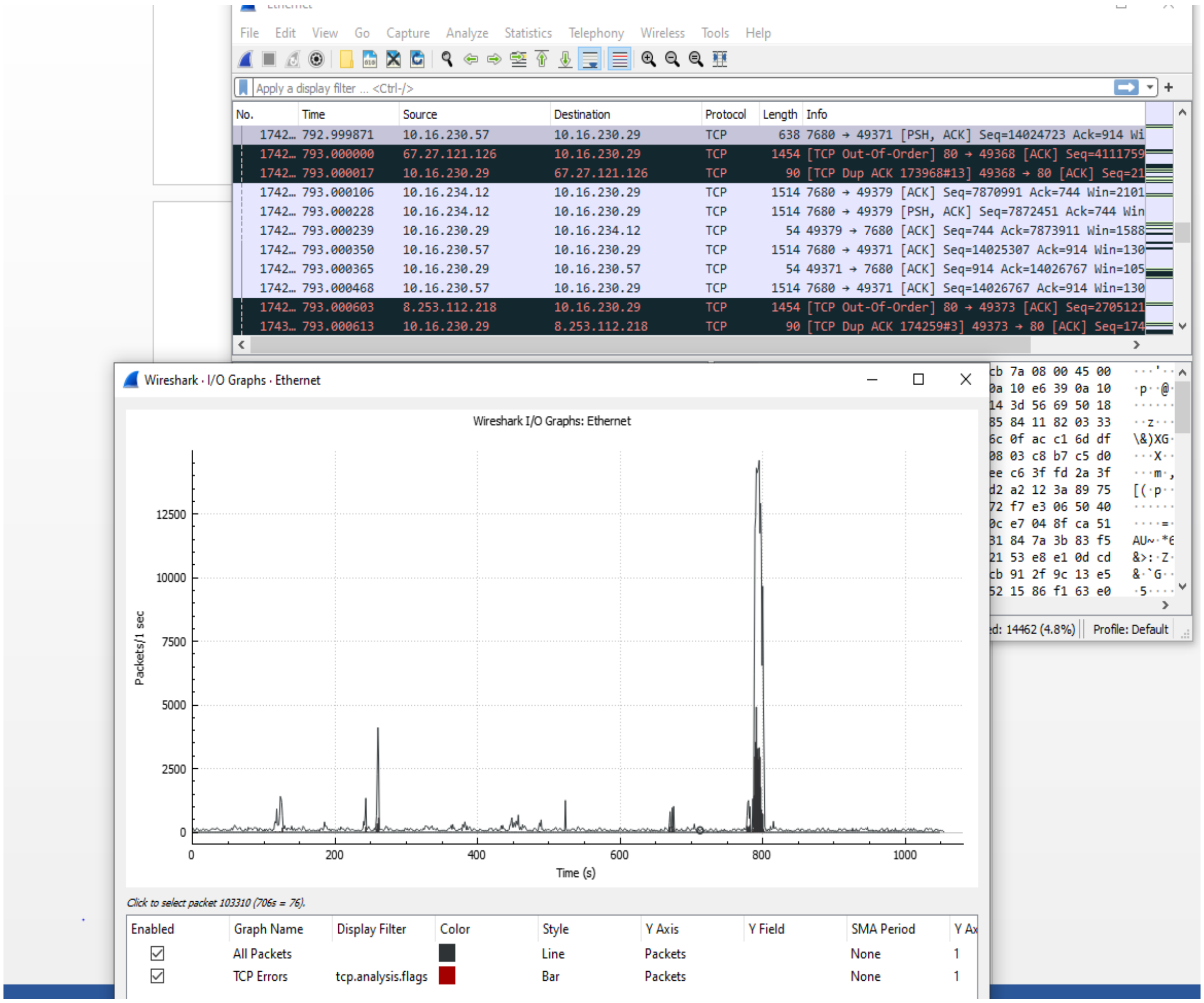


***Figure 4. 8 Issue with TCP out of order***.

We also saw the total amount of packets (299676) on the I/O graph. The protocol utilized TCP; the length of the packets was 1454, and the TCP Dup ACK 173968#13 from 10.16.230.29 to 67.27.121.126 at fig 4. 8. 3000 packets/s time in 800s show consequence of TCP out of order error from source IP addresses 67.27.121.126 to destination IP addresses 10.16.230.29.

When a sender receives a TCP DUP ACK, it indicates that the recipient has accepted a new out-of-order segment by sending a duplicate acknowledgment packet to the network. As a result, the packet that was not received is the one whose sequence number appears in the duplicate acknowledgment.

When a computer receives a TCP/IP packet out of order when attempting to connect with another computer via the TCP/IP protocol, it is referred to as an out-of-order segment and is ignored.

***Table 4. 5 illustrated the fig 4.8***

| no | Time | Source IP address | Destination IP address | protocol | length | info |
|---|---|---|---|---|---|---|
| 1742 | 793.000000 | 67.27.121.126 | 10.16.230.29 | TCP | 1454 | TCP[out-of- order]80 49368[ACK] seq = 4111759 |
| 1742 | 793.000000 | 10.16.230.29 | 67.27.121.126 | TCP | 90 | TCP [Dup ACK173968#13]49368-80 ACK Seq =21 |
| 1742 | 793.000603 | 8.253.112.218 | 10.16.230.29 | TCP | 1454 | TCP[out-of- order]80-49373[ACK] seq =2705121 |
| 1743 | 793.000613 | 10.16.230.29 | 8.253.112.218 | TCP | 90 | TCP [Dup ACK174259#3] 49373- 80[ACK] seq =174 |

The TCP retransmission error that we saw at the Figure 4.9 I/O window occurred between 600 and 700 s.

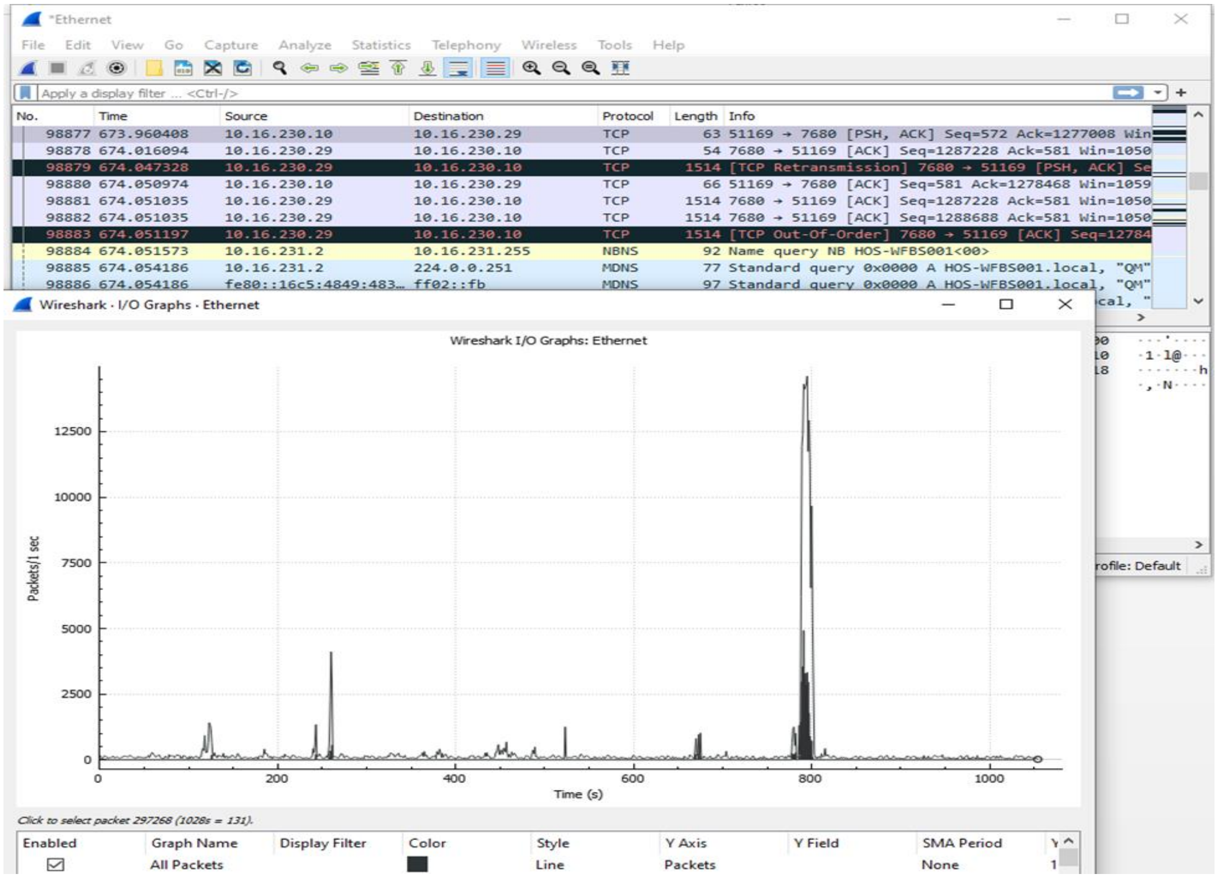


***Figure 4. 9 the TCP retransmission error is displayed*.**

According to fig 4.9 , we observed the time between 600s to 700s from the source IP address 10.16.230.29 to destination address 10.16.230.10 the length of the packet 1514 the packet information retransmission. Using the TCP Acknowledgment (ACK) flag, the recipient's receipt of the data is confirmed. The data is returned to the sender as confirmation that it has been received. In contrast, the PSH flag expeditiously pushes data to the application layer.

By using I/O graph window we observed at fig 4.10 graph the time between 1000s between 1050s packet 0 indicates broadcast problem that are used ARP protocol from the Source address Dell_af:39:14 to destination address broadcast and also source Dell_09:c1:4a to destination address broadcast.

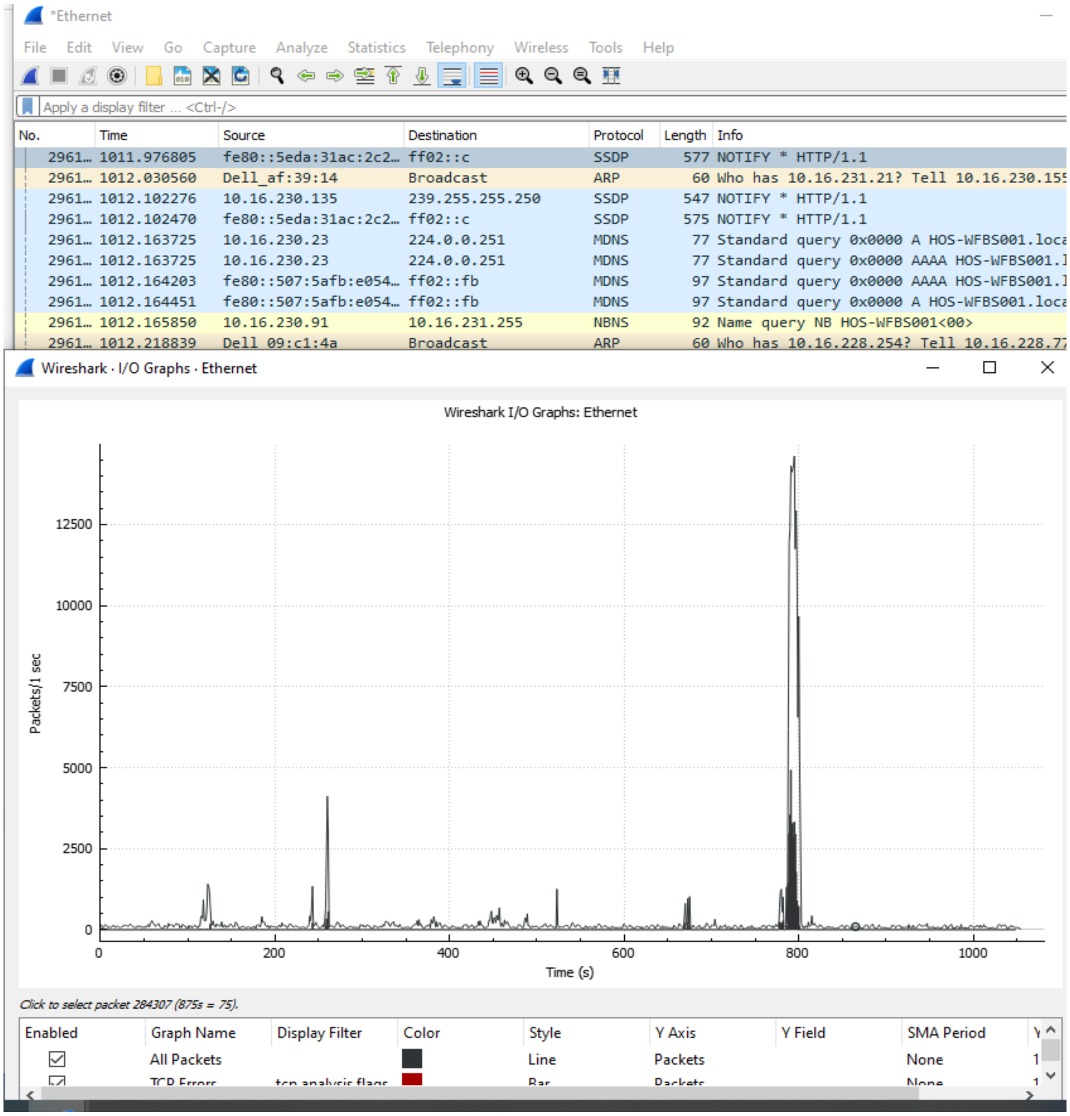

*Figure 4. 10 that shows the broadcast problem.*

We also filter the packet to detect the broadcast problem by using (eth.dst.lg == 1) or (eth.addr == ff: ff: ff: ff: ff:ff) as shown at fig 4.11.

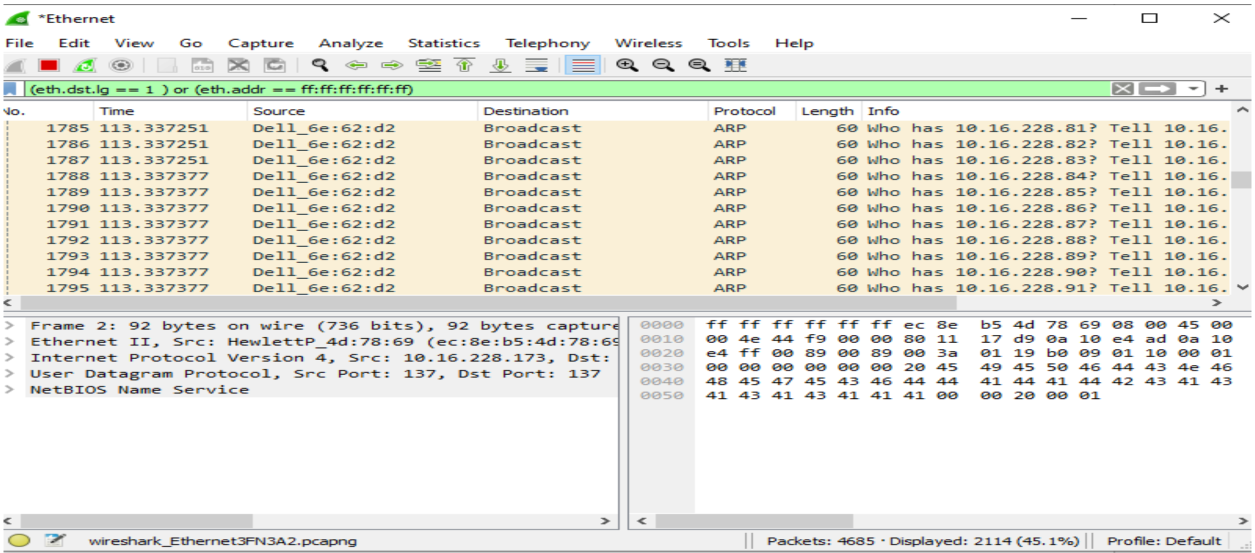


***Figure 4. 11 that shows broadcast problem.***

### 4.2.6 Flow graphs

We may create a graph with columns to show how traffic moves between two endpoints. We saw the broadcast issue in Fig. 4.12 from the source, huaweiTe_od:64:30, to the broadcast.

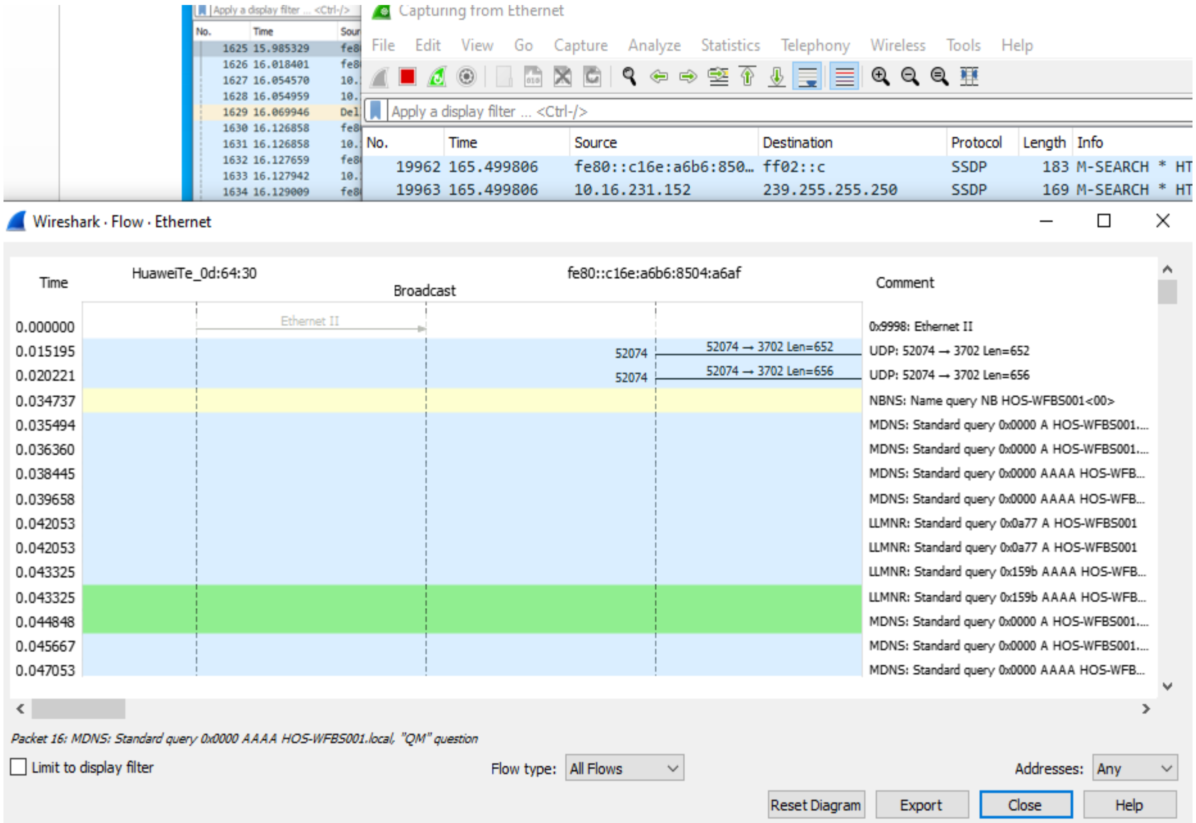


***Figure 4. 12 show that the flow graphs.***

### 4.2.7 Delays

We can quantify delay by measuring the time it takes for data to be sent from sender to receiver. In line with figure 4.13.

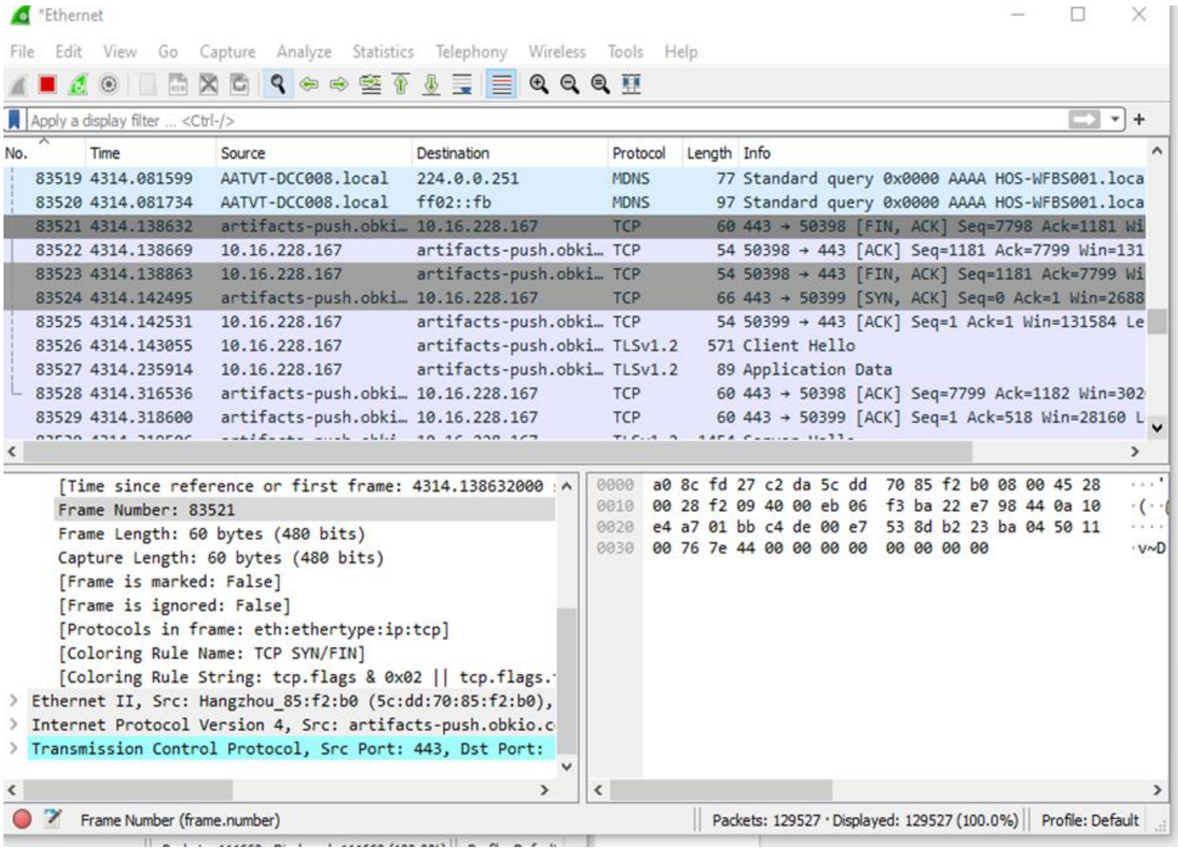


***Figure 4. 13 show that to measure the delays.***

Frame number: 83521 to calculate delay the time to send packet is 4314.138632s

Frame number: 83522 the time received packets is 4314.138669s

To calculate delay = the time takes to send packet- the time takes received packets

= 4314.138669s-4314.138632s

=0.00037s convert to milliseconds

= 375ms

The delay measure, according to Setiyo Budiyanto [12], In the ITU-T-T standard, the excellent delay category is the delay value < 150 Ms. So the result of 375 MS > 150 MS is a delay.

### 4.2.8 Response parameter

In Wireshark tool by filtering ICMP we got the result at fig 4.14.

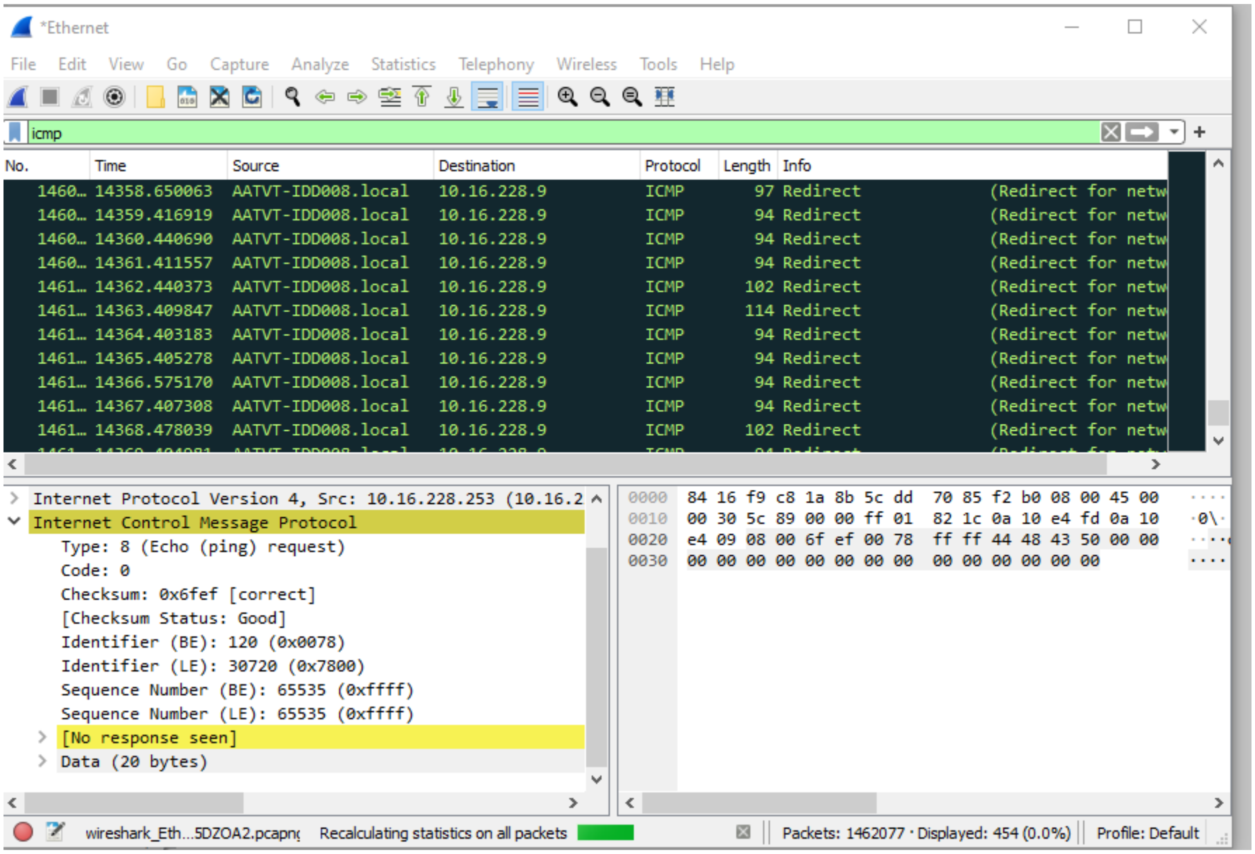


***Figure 4. 14 show that filtering ICMP.***

According to fig 4.14 by filter ICMP no response seen from source AATVT-IDD002.local to destination 10.16.228.9.

We also observed not response ICMP filter in expert information window as shown graph fig 4.15.

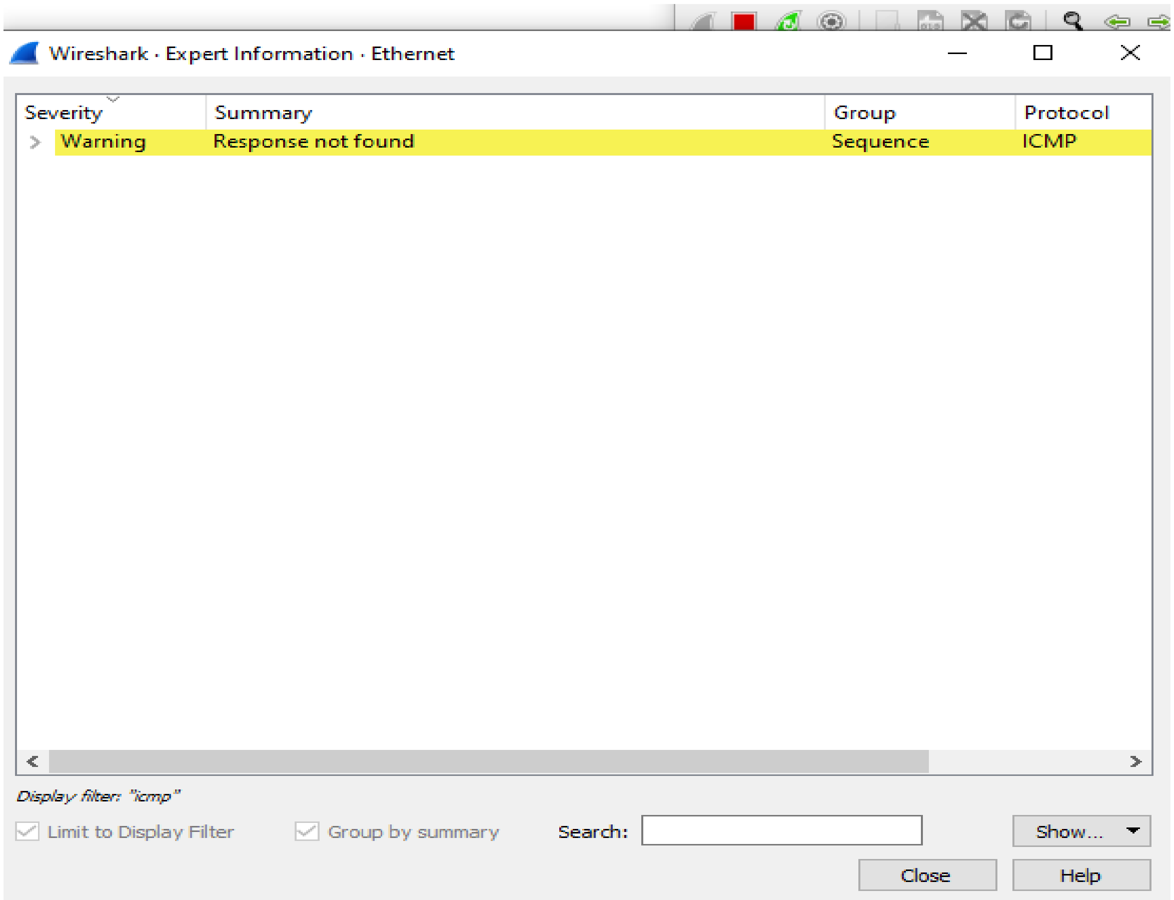


*Figure 4. 15 Expert information by filtering ICMP the result no response found*

#### 4.2.8.1 ARP traffic analysis

We utilize the ARP filter to determine the target mac address. Figure 4.16, which we saw in this study utilizing the ARP filter, shows that certain source addresses have been broadcast to destination addresses.

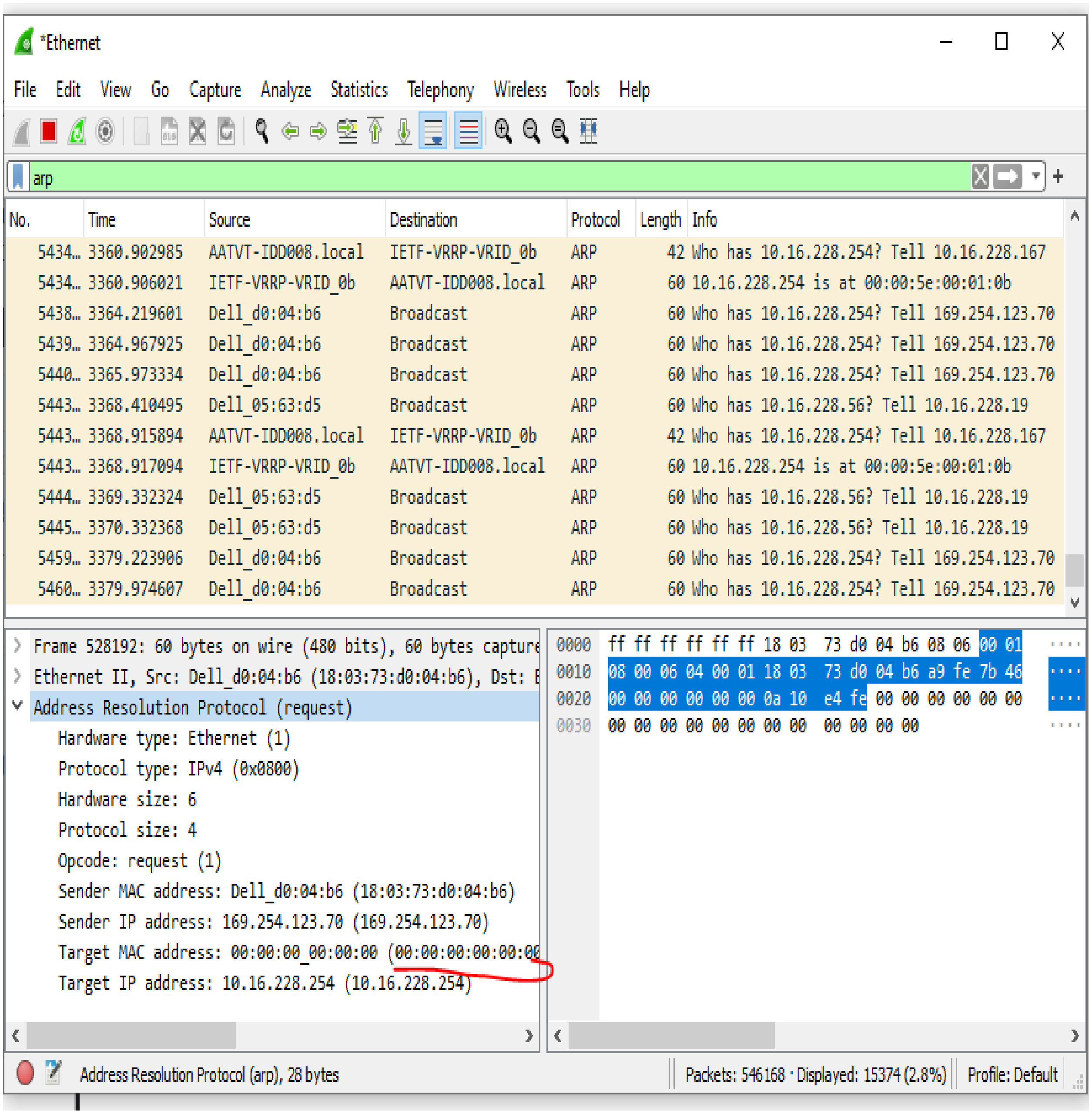


***Figure 4. 16 show that ARP filter analysis and capturing.***

By using Expert information window we viewed the result of the problem by filtering ARP as shown that the fig 4.17 the results duplicate IP address configured.

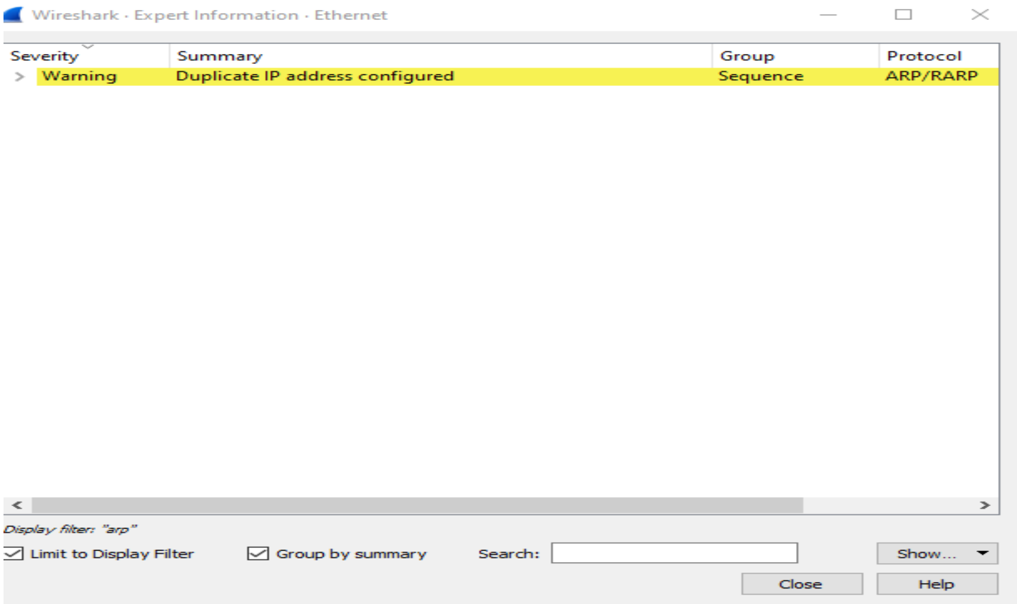


*Figure 4. 17 illustrate duplicate IP address configured by filtering the Arp filter.*

By using Wireshark tool we analyzed Addis Ababa public service & human resource bureau network performance and the following parameters have gotten these are high bandwidth utilization endpoints, packets loss, unstable throughput, delay, RTT, no response. The cause of this problems are some source IP addresses broadcasting to all destination IP address not to targeted IP address this lead to conjunction network that effect high bandwidth utilization and retransmission of packets and also caused IP conflicts.

## 4.3 Network performance analysis that are conducted from user perspective

The data gathered from the questionnaire about the network performance of the Addis Ababa public service and human resource bureau is presented and analyzed in this section. The questions were divided into three groups: those pertaining to network performance status, issues with network performance, and network performance enhancement. The questions are listed below, along with the answers to them.

### 4.3.1 Network performance status

Examining the organization's network performance status makes it easier to pinpoint the network issues that are causing the network to perform less well and to offer solutions for those issues.

***Table 4. 6 summary of respondents replay concerning network performance status.***

| Network performance status | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| The quality of service that the network offers its users is good, and network performance is currently at an excellent level. | 17.4% | 39.1% | 8.7% | 26.1% | 8.7% |
| The organization network is qualified in terms of availability. | 13% | 43.5 % | 8.7% | 30.4 % | 4.3% |
| When data transfer takes place from the source data sent to receiver side regarding to delay it may reason delays happen in the end point. | 4.3% | 4.3% | 21.7 | 52.2% | 17.4% |
| The transmission rate due to the data transmission regarding to the data successfully transmitted without any broken connection. | 17.4% | 52.2% | 13% | 8.7% | 8.7% |

Table 4.6: Addis Ababa public service &human resource bureau network performance status.

The questions categorized under the network performance status indicates the above table.

On the Network performance situation is good in terms of the quality of the service provided by the network to the user. Most of the respondents which cover 39.1 % of the total number of respondents disagreed with this idea and the least one which covers 8.7% of the total number of respondents are neutral and strongly agreed with this idea.

For the question regarding to the availability of organization network is qualified. The maximum number of the respondents which covers 43.5% are disagreed and the minimum number of the respondents which cover 4.3% strongly agreed with this idea.

The question of the data transferring between from the sender to receiver side delay happen the end point. Most of the respondent which covers 52.2% of the respondents is agreed and the least of respondents is 4.3% which strongly disagreed and disagreed.

The idea which state the transmission rate due to the data transmission regarding to the data successfully transmitted without any broken connection. The maximum number of the respondents which covers 52.2% are disagreed and the minimum number of the respondents which cover 8.7 % strongly agreed and agreed with this idea.

Generally the status of the network performance results indicates problems on delay, availability of the network, throughput and quality of services. According to the result of this problem the network performance must be optimized.

### 4.3.2 The problems of network performance

Accessing the problems of the network permanence helps the organization network to provide appropriate improvement solution. Summary of respondents on the problems of network performance presented in table 4.7 as follow.

***Table 4. 7 the problems of the organization network performance***

| Problems of the network performance | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| Network devices from the core switch to access switch has been used for a long time may affects the network performance. | 0% | 4.3% | 13% | 34.8% | 47.8% |
| The network that you are using in the organization that experience shortage of configuration can causes the network performance problem. | 4.5% | 9.1% | 0% | 50% | 36.4% |
| Absence of the preliminary maintenance within a certain period time for may affects the network performance. | 0% | 4.3% | 4.3% | 52.2% | 39.1% |
| The network devices in the organization network that are not | 4.5% | 4.5% | 4.5% | 50% | 36.4% |

| | | | | | |
|---|---|---|---|---|---|
| clean from dust affect the network performance. | | | | | |
| Devices advanced in years affected the network performance through its speed and security for the purpose of unpatched. | 0% | 8.7% | 4.3% | 52.2% | 34.8 |
| The network performance of the organization highly affected by the rate of bandwidth. | 4.5% | 9.1% | 27.3% | 31.8% | 27.3% |
| Your network's performance may be impacted by the physical transmission media devices that are used to transfer data across the network | 0% | 0% | 13% | 69.6% | 17.4% |
| The performance of your network may be significantly impacted by heavy usage of social media platforms. | 0% | 4.5% | 18.2% | 50% | 27.3% |
| The performance of your network is lowered by excessive bandwidth use. | 0% | 17.4% | 17.4% | 43.5% | 21.7% |
| The topology and network design of your system may have an impact on network performance. | 0% | 4.5% | 13.6% | 40.9% | 40.9% |
| The unequally between the number of the users and available network node may affect the network performance. | 4.3% | 21.7% | 4.3% | 39.1% | 30.4% |
| The network topology and design affect the network performance in terms of scalability, redundancy, security, and complexity. | 4.3% | 8.7% | 4.3% | 56.5% | 26.1% |

According to analysis report that are stated the above table most of the respondent responds strongly agreed and agreed regarding to the problems of network performance.

The question of Network devices from the core switch to access switch has been used for a long time may affects the network performance. Most of the respondents which cover 47.8% of the total number of respondents strongly agreed and 34.8% agreed with this idea. Currently the network device on the organization network from core to access switches, have been used for more than 10 years. According to the standard, the service life of a network device is maximum serve up to 5 years. So, one of the reasons that the network performance decreases are that the equipment is served more than ten years old.

The question of the network that you are using in the organization that experience shortage of configuration can causes the network performance problem. Most of the respondents which cover 50% of the total number of respondents agreed and 36.4% strongly agreed with this idea.

In the hardware perspective the network device from the core to access switches are due to the dust of the problem the fan not work properly and destroyed. As the reason of the fan not working properly the device has been hot that consequences configuration loos, no response. It's also affects the network performance & Reliability slow down such as network connection terminate, slow connection, network not work.

The question of Absence of the preliminary maintenance within a certain period time for May affects the network performance. Most of the respondents which cover 52.2% of the total number of respondents agreed and 39.1 % strongly agreed with this idea.

This result indicates that the preliminary maintenance within a certain period time must be done to provide solution on time and to protect sever problems.

The question of the devices advanced in years affected the network performance through its speed and security for the purpose of unpatched. Most of the respondents which cover 52.2% of the total number of respondents agreed and 34.8% strongly agreed with this idea. Older devices often end of life and service life occur when the product manufacturers stop patching and updates. In security perspective updates and patches stop it's affected by the treats and unauthorized person gain resource.

The network performance of the organization highly affected by the rate of bandwidth. Most of the respondents which cover 31.8% of the total number of respondents agreed and 27.3% strongly agreed and 27.3% neutral with this idea.

According to the question asked to the respondents about the physical transmutation media devices used for the data transmutation across the network may affect your network performance. Most of the respondents which cover 69.6%of the total number of respondents agreed and 17% strongly agreed with this idea. This indicates that currently using the transmutation media like cable it's served for long time and affected the network performance.

In the question the over utilization of bandwidth reduce your network performance. Most of the respondent's responses 43.5% agreed and 21.7% strongly agreed. Some users utilize more bandwidth that led the network performance degradation. To improve this solution must bandwidth management police solution.

The question of the great usage of social media platforms may strongly influence the performance of your network. Most of the respondent responds 50% of the respondents agreed and 27.3% strongly agreed. This indicate one of the performance degradation of the organization network is social media.

According to the question of network design of your network regarding to topology may affect the network performance. Most of the respondent's responses 40.9% agreed and 40.9% strongly agreed. This indicates that topology of the organization network is one of the network performance degradation. Currently the network topology of the devices of the organization network redundant for load balancing purposes but the ups problem all device not up on time this means the two ups are installed for all redundant device but only one ups work properly the other ups stop working. By this reason one ups did not addressed to up all device this leads the network delay and no response and unavailable network.

The question of the Inequality between the number of the users and available network node may affect the network performance. Most of the respondents which cover 39.1% of the total number of respondents agreed and 30.4% strongly agreed with this idea. This indicates that from the consideration of the network availability to address to all user this is one of the reason affect the network performance.

### 4.3.3 Network performance improvement

The proper remedy for the network's performance degradation issue is provided by the evaluation of network performance improvement. The table 4.8 mentioned provides a summary of the respondents' suggestions for improving network performance.

***Table 4. 8 network performance improvement solution.***

| Network performance improvement | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| The performance of the network in your company can be enhanced by replacing outdated devices with new ones in terms of speed, security, and stability (or availability). | 0% | 4.3% | 8.7% | 52.2% | 34.8% |
| The network traffics distribution over multiples serves or paths using load balancing techniques may improve availability and performance. | 0% | 4.3% | 0% | 65.2% | 30.4% |
| By using network performance tool analysis, the network problem and measured based on the metric can be solved by appropriate solution. | 0% | 8.7% | 8.7% | 52.2% | 30.4% |
| Compression can boost the network speed by lowering the amount of data packets; by caching (stores frequently visited data or content on a local or intermediate server). | 0% | 8.7% | 30.4% | 39.1% | 21.7% |
| By looking for and maximizing the similarity value between the | 0% | 4.3% | 8.7% | 69.6% | 17.4% |

| | | | | | |
|---|---|---|---|---|---|
| distorted source picture and the destination image, optimization can enhance network performance. | | | | | |
| Adding extra bandwidth can improve the organization network performance in terms of speed. | 4.3% | 13% | 17.4% | 52.2% | 13% |
| Change your network topology or hardware to address bottlenecks and performance issues. | 4.3% | 0% | 17.4% | 47.8% | 30.4% |
| The possible bottlenecks, weaknesses, and inefficiencies that require attention or improvement may be found by examining the network architecture and design. | 0% | 0% | 17.4% | 52.2% | 30.4% |
| You may avoid or lessen any network vulnerabilities, faults, or conflicts that could reduce the performance of the network by updating and upgrading the network hardware and software. | 0% | 4.3% | 8.7% | 47.8% | 39.1% |

Improve of the network performance analysis report that are stated the above table describe below.

In the question of the replacement of old devices with the new one can improve the performance of network regarding to speed of the network, security perspective, stable network (availability of the network) in your organization. Most of the respondents which cover 52.2% of the total number of respondents agreed and 34.8% strongly agreed with this idea. This indicates that the network performance is increase by the replacement of old devices with the new one. Because the new device have high capacity transfer rate, storage other resource to compare to old one this mean increase network performances in terms of speed, security perspective and stable network for the organization network.

According to this question the distribution of network traffic across multiple serves or paths to improve availability and performance by using load balancing techniques. Most of the respondents which cover 65.2%of the total number of respondents agreed and 30.4% strongly agreed with this idea. To address the availability of network and to increase speed load balancing necessary.

Based on this question of by using network performance tool analysis the network problem and measured based on the metric can be solved by appropriate solution. Most of the respondents which cover 52.2% of the total number of respondents agreed and 30.4% strongly agreed with this idea. This indicate that using the network analysis tool measure the network problems and fixing the bottleneck early is good to protect sever problems this technique insures to increase performance.

According to the question asked to the respondents the compression technique can increase the network performance.  Most of the respondents which cover 39.1% of the total number of respondents agreed and 30.4% neutral with this idea. This indicates according to Benfano Soewitoa [5], Compression on a WAN product is the shortening of a data frame to be transferred over the network using a certain compression algorithm approach. Reduced data size will result in space, bandwidth, and transmission time savings.

As stated in question of by adding extra bandwidth will increase the organization network performance. Most of the respondents which cover 52.2% of the total number of respondents agreed, 17.4% neutral and 13% responds disagreed and strongly agreed. This indicate adding bandwidth will increase the network performance.  To insure the good quality of services they should be done proper management of bandwidth unitization.

The question of change your network topology or hardware to address bottlenecks and performance issues. According to this question 47.8% of the respondent agreed, 30.4% of respondent strongly agreed, 17.4% neutral, 4.3% strongly disagreed and 0% of the respondent disagreed. This indicates that change the topology and hardware will increase the network performance.

The question asked to respondent about by analyzing the network topology and design, you can identify the potential bottlenecks, vulnerabilities, and inefficiencies that need to be addressed or improved. Most of the respondents which cover 52.2% of the total number of respondents agreed and 30.4% strongly agreed with this idea. This indicate analyzing the network topology and design are necessary to identified faults and problem of the network to provide appropriate solution or fixing the problem on time. This activates insures well the network performance.

In response to the question, you may avoid or lessen any network vulnerabilities, faults, or conflicts that might reduce network performance by updating and upgrading the network hardware and software. The majority of respondents 47.8% of the total agreed with this notion, and 39.1% strongly agreed. This demonstrates how maintaining and upgrading network hardware and software provides a high transmutation capacity to boost network performance and, from a security standpoint, ensures secrecy or shields hackers.

We used google form by analyzing the respondents of ICT users regarding to network performance problems of Addis Ababa public service human resource bureau are there is no a good quality of services, delay of network speed, the throughput not good, no available network. The main cause of this problems are outdated network device, configuration problem, high bandwidth usage, high usage of social media network, topology& design problems affect the network performance.

## 4.4 Summary of the result

In this study, the researcher examined the findings from two angles: first, by analyzing network traffic using the Wireshark tool; second, by using the questioner method to gather data from respondents who are specifically targeted as ICT directors, ICT leaders, and ICT experts about the organization's network performance.

### 4.4.1 Using Wireshark the researcher explore the following results

#### 4.4.1.1 Bandwidth utilization

Using the Wireshark tool the researcher explored top bandwidth utilization endpoint that are Table 4.1 and Table 4.2 illustrated.

Researchers examine the protocols which dispersed in the capture files and have the highest bandwidth usage using a Wireshark tool's protocol hierarchy pane. The findings of this study indicate that, of the packets distributed in the capture file, 90.5 percent were from the internet protocol version 4 (IPV4), while 62.2 percent were from the user datagram protocol. These results are displayed in Figure 4.3.

#### 4.4.1.2 Packets drops or loss

By using Wireshark tool the researcher explored the packet loss in the expert information tool we explored DNS response retransmission, response not found, malformed packet. That are showed at figure 4.4.

On Wireshark tool in the statistic menu using I/O (input out graph) the researcher explored the TCP out orders. 3000 packets /s time in 800s show result of TCP out of order error from the source IP addresses 67.27.121.126 to destination IP addresses 10.16.230.29 the protocol used TCP the length of the packets 1454 and the TCP Dup ACK 173968#13 from 10.16.230.29 to 67.27.121.126 shown in fig 11. Out-of-order segment means Each TCP/IP packet that is received out of order that is received by the computer during an attempt to communicate with another computer using the TCP/IP protocol is ignored.

By using I/O graph we also observed TCP retransmission error as shown at fig 4.9.

#### 4.4.1.3 TCP stream throughput graph

As seen in fig. 4.5, we noticed throughput instability. The greater throughput was 660000 bits/s, 420000 bits/s, and 180000 bits/s, whereas the lower throughput was 40000 bits/s and 20000 bits/s.

#### 4.4.1.4 TCP stream's Round Trip Time (RTT) graph

We measured network latency at this investigation utilizing a Round Trip Times (RTT) metric. We assessed the RRT graph's graph through employing its Transmission Control Protocol (TCP) streams graph along with the Wireshark program. An RTT plot is utilized to demonstrate a network's latency measurement in Figure 4.6. The RTT findings are briefly addressed on the table that follows.

RTT value<100ms is optimal latency.

The RTT between 100ms -200ms the performance likely affected.

The RTT >200ms performance degraded.

RTT more than 375 milliseconds commonly results in a connection being terminated.

In this work most of the results indicates RTT value 340ms observed that performance degraded,480ms ,460ms, 560ms ,420ms observed that means based on RTT >375 a connection being terminated. In this result the network is unavailable.

#### 4.4.1.5 Delay

When the data transmitted from senders to receiver time takes we can measure delay. According to fig 4.13 result the researcher explored the delay result.

Frame number: 83521 to calculate delay the time to send packet is 4314.138632s

Frame number: 83522 the time received packets is 4314.138669s

To calculate delay = the time takes to send packet- the time takes received packets

= 4314.138669s-4314.138632s

=0.00037s convert to milliseconds

= 375ms

The delay measure according to Setiyo Budiyanto [12]. ITU-T standard, the excellent delay category is the delay value < 150ms. So the result 375ms >150ms is delay.

We also filter the packet to detect the broadcast problem by using (eth.dst.lg == 1) or (eth.addr == ff: ff: ff:ff:ff:ff) as shown at fig 14. Fig 15 we observed the broadcast problem from the source huaweiTe_od:64:30 to broadcast.by filter ARP in Fig 19 as shown the broadcast problem observed and ARP filtering using the expert information window we detected duplicate Ip address configured as shown in fig 20. This indicates the broadcast result shows its effects more bandwidth utilize, delay traffic, increased latency and reduced throughput, leading to slower response times and reduced efficiency.

#### 4.4.1.6 Response parameter

In Wireshark tool by filtering ICMP we got the result at fig 4.14. According to fig 4.14 by filter ICMP no response seen from source AATVT-IDD002.local to destination 10.16.228.9. We also observed not response ICMP filter in expert information window as shown graph Fig 4.15.

### 4.4.2 Using the questioner method researcher explore the following results

The network performance status of the organization that collected from the respondents of ICT director, ICT team leader, ICT expert describe as below.

According to the status of the organization network performance as shown in table 4.6 indicates most of the respondent response in the quality of service 39.1% of respondents disagreed with this idea that stated there is a high quality of service, availability of network performances 43.5% of the respondent disagreed with the presence of the network connection, delay of the network 52% agreed with slow up network performance in terms of speed and the transmission of the data transferred without intermittent 52% of the respondents disagreed with this idea.

As stated to the problems of the network performance as shown in table 4.7 indicates 47.8% of the respondent strongly agreed with the network device that are used for a long time may affects the network performance, 50% of the respondents agreed with the idea that state the shortage of configuration can affect the network performance, 52.2% of the respondents agreed with the absence of preliminary maintenance can affects the network performance, 31.8% of the respondents agreed with the rate of bandwidth affects the network performance, 69.6% of the respondents agreed with the transmission media of the organization network affects the network performance,43.5% of the respondents agreed with the over utilization of bandwidth reduce your network performance,56.5% of the respondents agreed with the network design and topology affect the network performance.

Table 4.8 illustrates how respondents felt about improving network performance. Of them, 52.2% agreed that replacing an outdated device with a new one can boost performance. 65.2% agreed that using load balancing can ensure network availability and boost performance. 52.2% agreed that using a network analysis tool can improve performance. 52.2% agreed that adding additional bandwidth can improve performance. 39.1% agreed that compression can improve performance by reducing the size of data packets. 47.8% agreed that changing your network's hardware or topology can address bottlenecks and performance issues. Finally, 47.8% of respondents agreed that.

In general according to the respondents responded the questioner we summarize the presence of the delay in the network environment, no availability of network, the overutilization of bandwidth. The cause of networks performance problems in this organization the researcher explored based on the ICT experts respondents the devices are old, shortage of configuration means the network infrastructure has been used for a long time and it experiences different ICT network administrator and this leads the lack of information beside it is not recorded that consequences are unmanaged. As result of this it is difficult to maintain on time due to different configuration, absence of preliminary of maintenance, transmission media, lack of proper the network design and topology explored based on the respondents.

## 4.5 Proposed framework solution for network performance optimization

In order to address the issues raised in the interview and the Wireshark tool analysis results, we have put up a workable framework for improving network efficiency. These issues include the top bandwidth utilization endpoint, packet loss and drops, unstable throughput, RRT (round trip time), delay, no response, and the use of a questioner to gather information from ICT directors, ICT team leaders, and ICT experts regarding the occurrence of network delays, lack of network availability, and excessive bandwidth use. The optimization framework consists of several steps, one of which is identifying the bottleneck via enhancing network performance.

The suggested framework calls for the following: defining the key performance indicators (KPIs) using a tool for network performance analysis; checking the topology and design of the network; applying optimization techniques into practice; keeping a close eye on network performance both defensively and regularly; updating and upgrading both software and hardware; and providing instruction to network administrators and users. The propose framework listed below the following figure 4.18.

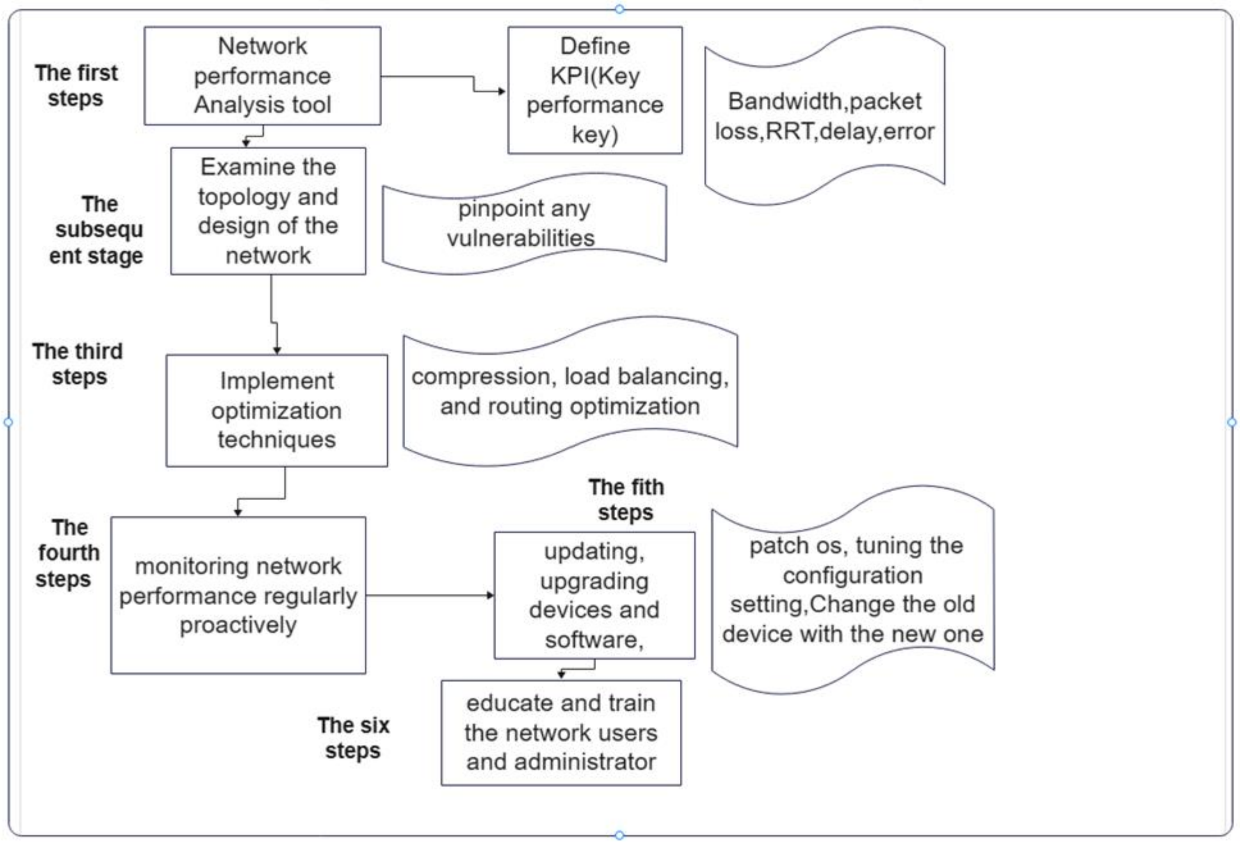


*Figure 4. 18 displays the proposed framework for network performance optimization.*

### 4.5.1 KPIs, or key indicators of performance)

Networking indicators of performance (or KPIs are often employed to quantify ideal network efficiency. Within the metrics utilized to evaluate the performance of networks are the bandwidth, delays, loss of packets, throughput, the availability, as well as rate of error. Networking analyzer tools which utilize are able to be for investigating these types of metrics. Through defining the metrics, the foundation, benchmarks, the objectives for network performance improvement could be found.

### 4.5.2 Analyze the network topology and design

The layout of a network's nodes and the connections or connections established between them are known to as its topology. The structure of a network influences an extensive variety of network characteristics, such as efficiency, reliability, performance, and complexity.

Network diagrams, documentation, and maps can be utilized to show and comprehend the topology and design of a network. We are able to find any bottlenecks, faults, and inefficiencies that require attention by examining the network's architecture and design.

### 4.5.3 Apply methods for network optimization

Step three involves using network optimization techniques to enhance network performance in line with the designated goals and KPIs. Load balancing, which divides network traffic among many servers or routes, is one specific technique to increase availability and speed rapidly. Data that is often requested might be cached on a local or intermediate server; compression is a technique for minimizing data packets.

### 4.5.4 Track and address problems in network performance

The fourth phase encompasses proactive, routine network efficiency monitoring as well as troubleshooting. Monitoring and troubleshooting entail utilizing a range of tools & procedures to gather, examine, as well as report network efficiency indicators & data. Debugging and efficiency tracking enable the identification and repair of any problems, mistakes could affect the network's efficiency. The effectiveness and efficacy of network enhancement methods and ideas may also be assessed via the utilization of data and measurements regarding network performance.

### 4.5.5 Update and upgrade network devices and software

The fifth thing to do is to periodically patch and improve the network's hardware and software. In order to guarantee network compatibility, security, and functionality, the most recent modifications, patches, features, or versions of network hardware and software need to be deployed. By repairing and enhancing the network hardware and software, they can avoid or eliminate network shortcomings conflicts, or vulnerabilities that may hinder network performance. Moreover, you hope to benefit from newly developed technologies or better network features that could enhance the performance of your network.

### 4.5.6 Educate and train network users and administrators

Offering network managers and user’s guidance and training on the best practices and standards for boosting network performance is the sixth and last phase. The aim of education and training is to offer network users and administrators with the expertise, abilities, and rules they need to effectively and effectively operate and maintain the network. By informing and instructing network administrators and users, they can promote a culture of network performance optimization that promotes network awareness, accountability, and working together.

## 4.6 Validation of the Network Performance Optimization Framework

The AA Public Services and Human Resource Bureau scenario involved the validation of the network performance optimization framework in a real-world situation. Senior ICT professionals who utilize the public service and human resource network were given the built framework, and they had a discussion. In order to assess the recently created framework for network performance improvement, the researcher readies the person being questioned.

The usefulness of the developed framework was assessed by the senior ICT expert of the public service and human resources bureau network users. Ten senior public service &human resource network user of senior ICT experts are actively participated to evaluate the proposed network performance optimization framework.

The feedback that the public service & human resource bureau Network users of Senior ICT experts (evaluators) provided on the established Network performance optimization Framework for its applicability is summarized in Table 4. 9 below.

**Table 4. 9 Validation questioner for optimization framework**.

| **Evaluation Criteria** | **Poor** | **Fair** | **Good** | **Very Good** | **Excellent** |
|---|---|---|---|---|---|
| How well do you think you grasp the developed network performance optimization framework in general? | | | 10% | 20% | 70% |
| How relevant do you think the optimization framework is? | | | | 30% | 70% |
| The proposed framework contains all important aspect | | | 10% | 30% | 60% |
| The optimizing framework that has been suggested Simple to employ. | | | | 20% | 80% |
| The suggested structure aids in resolving the network performance problem. | | | | 30% | 70% |

| Evaluation Criteria | Poor | Fair | Good | Very Good | Excellent |
|---|---|---|---|---|---|
| The suggested framework's substance is obvious. | | | 10% | 10% | 80% |

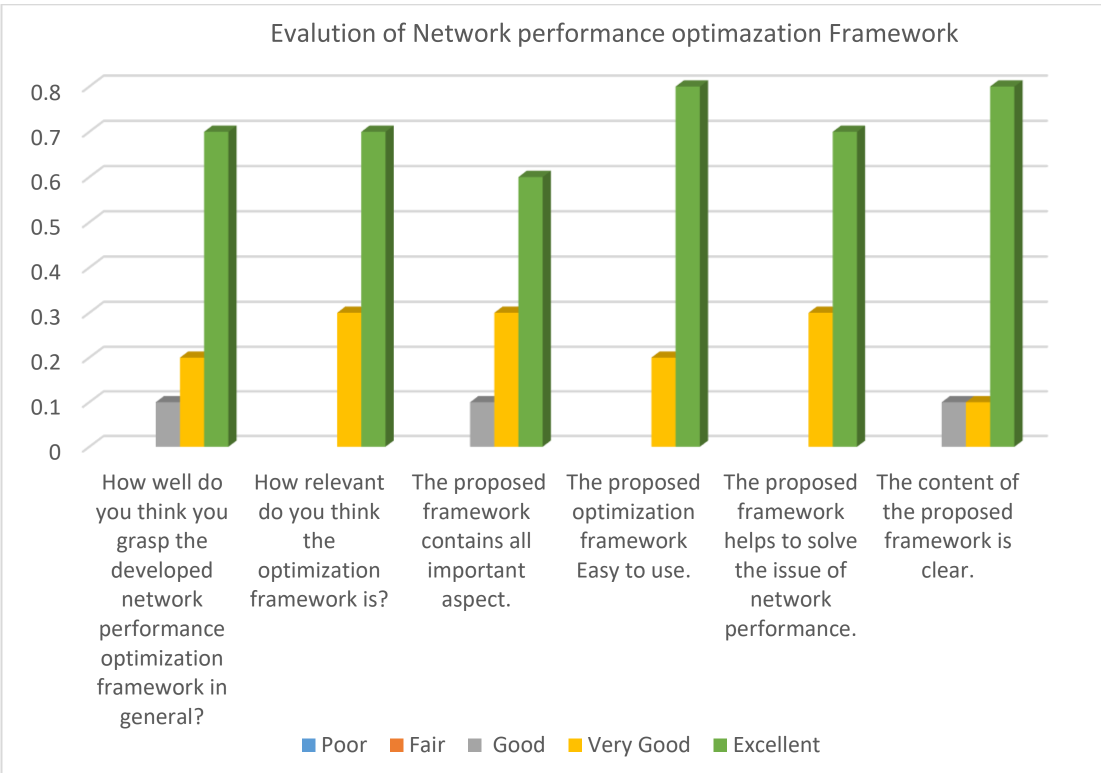


***Figure 4. 19 Illustration the evaluation of network performance optimization frame work***

As illustrated table 4.9 and figure 4.19 the above 70% of the participants demonstrated a clear understanding of the optimization framework as excellent, 20% of the respondents very good and 10% good.

The relevant of optimization framework judged as excellent 70% and 30% very good.

60% of the respondents excellent in the case of the suggested framework includes every significant element, 30% of the respondents very good and the rest of 10% the respondents good.

The suggested optimization framework considering to user friendly 80% of the respondent are excellent and 20% very good.

Regarding the suggested framework's ability to tackle the network performance issue, 70% of respondents grade it as excellent and 30% very good.

The clarity of the proposed framework 80% of the respondent’s excellent, 10% very good and10% good.

According to the ICT expert’s analysis of the respondents' data, our framework has a promising and encouraging applicability in addressing the issue of network performance in the organization network environment.

## Performance

A researcher has identified that to optimize a network performance by validation technique. Hence as above Table 4.9 and figure 4.19 shows that using the framework optimization increases a network performance.

As above depicted each questions regarding to optimization framework the respondents replied that the proposed optimization framework is excellent which shows that the average percentage is 70%.

**The process of validating and establishing a framework**

The validation process for implementing the network performance optimization framework has been completed by senior ICT experts. By validating the framework, we have outlined the six phases of the process as follows:

1. To begin, we pinpoint the bottleneck in network performance through an examination of network performance, allowing us to gain a clear understanding of the network's status. Subsequently, we define Key Performance Indicators (KPIs) for performance evaluation, utilizing the metrics listed below:
    - Elevated bandwidth utilization
    - Instances of packet loss
    - Presence of latency
    - Throughput problem
2. To enhance the network's performance, scalability, and reliability, we addressed design and configuration issues stemming from performance problems.

3. By optimizing our processes, we have enhanced the quality of services. This optimization allows us to measure network performance effectively, leading to reduced latency, increased throughput, decreased packet loss, and lower high bandwidth utilization.
4. Through proactive monitoring, we ensure stable network performance and enhance overall performance.
5. Enhancements and advancements yield concrete, verified outcomes that enhance network performance and capacity.
6. Training users leads to a decrease in support issues and enhances the efficient utilization of network resources.

The successful approval of the proposed framework would demonstrate the following:

- Clear progress in assessing network performance.
- Enhanced network reliability, flexibility, and security.
- Increased efficiency in managing and operating networks.
- Improved customer satisfaction and productivity.

Each phase's effective approval contributes to the generally victory of the system in optimizing network performance successfully.

# CHAPTER FIVE

# 5 CONCLUTION AND RECOMMENDATIONS

## 5.1 Conclusion

In conclusion, this study has addressed the critical issue of poor network performance within the Addis Ababa Public Service and Human Resource Bureau by proposing a comprehensive framework for optimization. Through Wireshark analysis, questionnaires, interviews, and observation, several underlying network performance issues were identified. These issues, ranging from excessive bandwidth usage to configuration problems and device aging, significantly hindered the bureau's ability to deliver quality services effectively. However, by meticulously analyzing key metrics such as packet loss, response time, latency, and network availability, a tailored framework for network performance optimization was developed.

The proposed framework offers practical solutions to address the identified issues and improve overall network performance. By focusing on routine maintenance, device upgrades, and configuration enhancements, the bureau can mitigate network disruptions and ensure smoother operations.

Overall, this study underscores the importance of proactive network management and optimization in enhancing organizational efficiency and service delivery. Implementing the proposed framework can position the Addis Ababa Public Service and Human Resource Bureau for improved performance and better service provision in the future.

## 5.2 Recommendations

The research findings suggest that the following recommendations should be pursued as a direction for future studies:

- In this research, we only study the wired network environment. For future work, we will recommend studying the application area. It also we recommended for wireless network traffic analysis study will be done in the future work.
- In this study, only generally wired Ethernet traffic analysis was done. In future work, we will recommend specific studies like bandwidth studies and WAN network studies.

- We recommended to the organization IT staff that they implement an ICT policy for control mechanisms.
- The configuration of the network device in the organization should be recorded for future use by any ICT expert for easy troubleshooting purposes.
- We recommend that primary maintenance be done within a certain period of time before the problem occurs.

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# 7 Appendix A: Questionnaire

I am conducting a research which aims to propose Network optimization framework for the Addis Ababa public service& human resource bureau, as part of the partial fulfillment of the Master's Degree in computer science, at St. Mary's University.

This questionnaires are prepared to collect the necessary data on network performance status and problems of network performance to propose network performance framework. Optimization framework.

Please put a tick mark (√) or an (×) sign for your selection in the corresponding box. If you have any questions about this research in general and the questions in particular, you may contact me using the following address.

Tigist Degineh Tel: 0911546417 email: Tigist.Degineh@gmail.com

**St. Mary's University Faculty of Informatics MSC program**

**SECTION A: General information about the respondent**

Instruction: please indicate your response by selecting in the appropriate box provided

1. Gender information

   ☐ Male ☐ Female

2. Level of Education:

   ☐ 10+3 ☐ Diploma ☐ BA/BSc ☐ MA/M.Sc.

   PHD ☐ Other:________________

3. Field of Study:______________________________________
4. Position Currently you hold: ____________________________________________

5. Experience since you joined this organization

☐ 3 to 6 years ☐ 7 to 10 years ☐ more than 10 years

## SECTION B: Question related to the status of the network performance

| Please put a mark depending on the degree to which you agree with the statements.<br>1. Strongly disagree 2. Disagree 3.Neutral 4. Agree. 5. Strongly agree | | | | | | |
|---|---|---|---|---|---|---|
| No | **According to network performance status** | 1 | 2 | 3 | 4 | 5 |
| 1 | The quality of service that the network offers its users is good, and network performance is currently at an excellent level. | | | | | |
| 2 | The organization network is qualified in terms of availability | | | | | |
| 3 | When data transfer takes place from the source data sent to receiver side regarding to delay it may reason delays happen between the end point. | | | | | |
| 4 | The transmission rate due to the data transmission regarding to the data successfully transmitted without any broken connection. | | | | | |
| | **The problem of the network performance** | 1 | 2 | 3 | 4 | 5 |
| 5 | Network devices from the core switch to access switch has been used for a long time may affects the network performance. | | | | | |
| 6 | The network that you are using in the organization that experience shortage of configuration can causes the network performance problem. | | | | | |
| 7 | Absence of the preliminary maintenance within a certain period time for may affects the network performance. | | | | | |
| 8 | The network devices in the organization network that are not clean from dust affect the network performance. | | | | | |
| 9 | Devices advanced in years affected the network performance through its speed and security for the purpose of unpatched. | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 10 | The network performance of the organization highly affected by the rate of bandwidth. | | | | | |
| 11 | Your network's performance may be impacted by the physical transmission media devices that are used to transfer data across the network. | | | | | |
| 12 | The performance of your network may be significantly impacted by heavy usage of social media platforms. | | | | | |
| 13 | The performance of your network is lowered by excessive bandwidth use. | | | | | |
| 14 | The topology and network design of your system may have an impact on network performance. | | | | | |
| 15 | The inequality between the number of the users and available network node may affect the network performance. | | | | | |
| 16 | The network topology and design affect the network performance in terms of scalability, redundancy, security, and complexity | | | | | |
| | **Network performance improvement** | 1 | 2 | 3 | 4 | 5 |
| 17 | The performance of the network in your company can be enhanced by replacing outdated devices with new ones in terms of speed, security, and stability (or availability). | | | | | |
| 18 | The network traffics distribution over multiples serves or paths using load balancing techniques may improve availability and performance. | | | | | |
| 19 | By using network performance tool analysis the network problem and measured based on the metric can be solved by appropriate solution. | | | | | |
| 20 | Compression can boost the network speed by lowering the amount of data packets; by caching (stores frequently visited data or content on a local or intermediate server) | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 21 | By looking for and maximizing the similarity value between the distorted source picture and the destination image, optimization can enhance network performance. | | | | | |
| 22 | Adding extra bandwidth can improve the organization network performance in terms of speed. | | | | | |
| 23 | Change your network topology or hardware to address bottlenecks and performance issues. | | | | | |
| 24 | By analyzing the network topology and design, you can identify the potential bottlenecks, vulnerabilities, and inefficiencies that need to be addressed or improved. | | | | | |
| 25 | You may avoid or lessen any network vulnerabilities, faults, or conflicts that could reduce the performance of the network by updating and upgrading the network hardware and software. | | | | | |

# 8 Appendix B: Optimization framework Validation questioner

Put a number (1-5) for your evaluation in the corresponding box of evaluation criteria according to the following: (1) poor, (2) fair, (3) good, (4) very good, and (5) excellent.

| Evaluation Criteria | Poor | Fair | Good | Very Good | Excellent |
|---|---|---|---|---|---|
| How well do you think you grasp the developed network performance optimization framework in general? | | | | | |
| How relevant do you think the optimization framework is? | | | | | |
| The proposed framework contains all important aspect | | | | | |
| The optimizing framework that has been suggested Simple to employ. | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| The suggested structure aids in resolving the network performance problem. | | | | | |
| The suggested framework's substance is obvious. | | | | | |

*Table 14: Evaluation check point*