INBOUND AND OUTBOUND INTERNET APPLICATION SERVICES QOS ANALYSIS ON LAN METRO-E NETWORK

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ABSTRACT

This paper presents an analysis of internet application services utilization on the Local Area Network (LAN) Metro-E network. A recent problem identified that the internet line has been upgraded frequently, but still, the campus faced internet link congestions time by time. The Quality of Services (QoS) on the internet LAN faces the same problem. This study presents the performance analysis of internet application services on LAN Metro-E Network. The data was collected using the Exinda Network Orchestrator, which was set to monitor and control the network throughput. Six months of data were collected on the campus Metro-E network at the main gateway to the internet. The result presents a classification of the top 10 internet application categories used in the network. Inbound and outbound data were analyzed based on the maximum and minimum throughput on the network. The top three inbound application services are others, YouTube and Steam applications, respectively at 70.82%, 20.88%, and 1.94%. Meanwhile, the top three outbound services are others, iCloud and TCP 902-52640 respectively at 82.86%, 5.63% and 5.10%. The Pareto distribution model was identified for both inbound and outbound internet LAN Metro-E network traffic analysis. This research is significant in deploying traffic scheduling, policing, and shaping future QoS on the LAN Metro-E Network.

Keywords: *Internet Application Services, Performance Analysis, Throughput, Quality of Services (QoS), LAN Metro-E, data network*

1. INTRODUCTION

The rapid development of internet application services requires the latest hardware and software, especially on LAN campus networks. Internet technology is increasingly playing a crucial role in enabling the Internet to connect every individual around the world without any restrictions. Analysis and prediction of network traffic have become crucial for monitoring networks. The process of capturing network traffic and extensively examining it to determine what is occurring in the network is defined as network prediction. The quality of service (QoS) of internet applications must be ensured in terms of delay, bandwidth, jitter, reliability, or a combination of these parameters, given the rapid growth of internet applications[1]. Although the network speed is continuously being increased to accommodate the increased number of internet application services, traffic bursts in the network are still occurring. This has impacted network management's quality of service (QoS), which includes bandwidth, processing speed, and performance. Due to the significant demand of today's businesses and commercial enterprises on fast internet, reliable QoS of network traffic can be achieved using essential and appropriate network control and monitoring technologies, which in turn would improve connections. As comprehend the situation of internet traffic, real-time network traffic analysis must be performed. The young generation now makes up the majority of social media users, making it the most widely used platform[2]. The use of online video meeting applications, such as Zoom, Google Meet and Skype, is increasing significantly[3]. Low latency and faster throughput are requirements for a variety of interactive network applications. Today, using the internet in our daily lives is no longer an option. With digital platforms for various purposes, people feel secure and digitally independent in completing their tasks. In the current digitalized world, everything is interconnected and accessible from everywhere. Campus network involves high-performance networks in terms of quality of service (QoS) parameters such as delay, throughput, bandwidth, and security. Internet access applications show an increasing trend of utilization. The campus traffic focuses on collaboration and remote working platforms usage, remote teaching adoption, and also looks for changes in unsolicited/malicious traffic where utilization of the application is in high demand[4]. Internet Applications are the type of applications that use the internet in network operation. Those applications mostly support internet communication, sharing a file, and sharing information from the respective server systems. These services can be accessed with permission from the organization's network, facilities, and good support on the internet line. Most of the campus network used Local Area Network as their network architecture.

A local area network (LAN) is a computer network that spans an entire building and is managed by a single LAN. A LAN is a group of computers connected in a small geographic area to communicate with each other via wired or wireless links and share resources such as printers and network storage. In LANs, they are mainly used to create backbone cable channels between buildings and within buildings, while providing higher data transfer rates between segments of these networks[5]. Bandwidth allocation is proposed for the LAN system to make sure it significantly outperforms in terms of average latency, network throughput and load balancing performance[6].To ensure the stability of the network's performance, internet service providers apply a quality of service (QoS) approach to network access. QoS is used to measure the quality of internet bandwidth running on a LAN. QoS is taken as a guideline for network servicing to reach its full capacity and to compromise several network performance attributes such as latency, jitter and packet loss[7].

Todays, network found that the increased of internet traffic was gradually increased from the growth of internet application services. Burst of internet traffic has impacted the quality of service (QoS) in network management, including bandwidth, processing speed and performance. QoS bandwidth and network traffic can be monitored and regulated by using suitable traffic control and techniques such as enhancing connections, scheduling, policing, and shaping internet traffic. Thus, internet traffic, analysis of real-time network traffic is crucial.

This paper presents a study on analyzing internet application services traffic on the LAN Metro-E network. The aim of the study and outcome measure is to improve the bandwidth management on metro-E network. This performance analysis able to help the network management as guidance and reference to manage internet-protocol bandwidth management on the Metro-E campus or other networks in providing best QoS of internet traffic management. Data were collected for 6 months in the year 2022 on the campus network. Internet traffic packet and throughput were analyzed based on four key areas: group internet apps, top URL utilizations, and inbound and outbound traffic.

2. LITERATURE REVIEW

2.1 LAN Metro-E

Local area network (LAN) is a useful way for end users to share resources. The application of the load balancing service on a LAN produces an equilibrium network session over multiple connections to spread out the amount of bandwidth used by each user like browsing websites and accessing email[8]. A campus network was created by interconnecting a group of LANs that are spread over a local geographic area. Campus network design concepts include small networks that use a single LAN switch, up to very large networks with thousands of connections. LAN segments are built in distributed branch offices to serve the institution's business objectives according to its needs[9]. Figure 1 shows the LAN Metro-E campus network. Ethernet gradually goes beyond the applications within LAN cause of its advantages such as better price-performance ratio per Mb bandwidth, and become one of the leading networking technologies for Metropolitan Area Networks (MAN)[10].

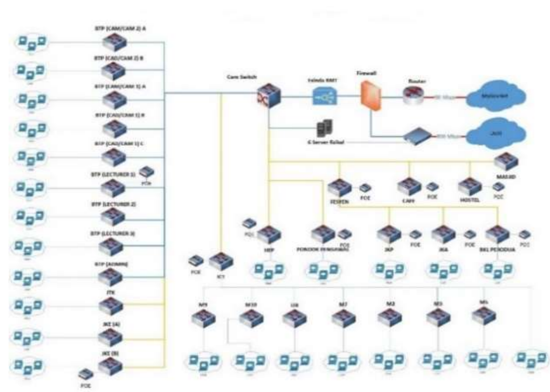

Figure 1: LAN Metro-E Campus Network Diagram

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2.2 Inbound and Outbound Throughput

The large user scale and the increasing equipment draw higher demand for bandwidth, reliability and users' Internet experience of the campus network. To ensure that internet access can meet the needs of users and high-performance service packets need to reach their destination successfully, monitoring network throughput is crucial for organizations looking to monitor the real-time performance of their network and successful packet delivery[11]. Throughput refers to the maximum rate at which a device can transmit the maximum amount of packet data that can be transmitted per unit of time from the source sender to the destination receiver without packet loss[12]. Network throughput is measured as an average figure used to represent the overall performance of the network. The specific monitoring index is the inbound throughput of the link because the inbound traffic of the campus network brings much more load pressure to the link than the outbound traffic[13].

2.3 Bandwidth Management

Traffic congestion and slowdowns during data transmission are avoided using bandwidth management. Inbound and outbound traffic can be divided into application and service categories through bandwidth management. To optimize network performance, the efficient utilization bandwidth, route loss rate, and latency should all be monitored. Lacking bandwidth management, internet apps are unable to use all the available bandwidth, and other applications are unable to share the network. Streaming media like YouTube, Netflix, and Facebook among others put pressure on the campus network's bandwidth[14]. Efficient bandwidth utilization and optimization in effective networks to make sure the higher the bandwidth available, the better the network performance [15]. Bandwidth-hungry video services change traffic consumption by users and services, while social messaging applications boom (and vanish) at an incredible pace[16].

2.4 Internet Application Services

The rapid development of today's internet applications causes very large and fast traffic to be required due to several different dynamic applications and services. Most of the traffic is generated by popular video hosting services, such as YouTube, Netflix, and others, which use Dynamic Adaptive Streaming over HTTP technology[17]. Online streaming, Video on demand, P2P, e-commerce and e-banking are the most popular applications nowadays. To deliver live and on-demand video streaming services on the Internet at low server cost, numerous P2P streaming systems have been deployed using the peer-to-peer (P2P) networking architecture[18]. The most used applications during the pandemic are YouTube followed by Netflix, Facebook, WhatsApp, and Skype. There are numerous internet-based applications, including social networking sites, online video streaming services, and the newest cloud computing technologies[19]. Consumer acceptability of cloud computing services depends heavily on their quality.

2.5 QoS Internet Promising

Quality of service (QoS) is dependent upon different network parameters, if routing performance is maximized means automatically throughput is also automatically enhanced[20]. QoS has two meanings from the perspective of network service, the overall quality of service of a network business usually uses the transmission bandwidth, delay, packet loss rate, and other indicators to summarize and evaluate the network service and more broadly QoS is not only referring to the quality of service but also refers to a series of assurance measures to ensure the quality of services[21]. Various QoS control methods can be used to guarantee the required levels of low latency, packet error loss, and high priority[22]. One of the biggest challenges facing the Internet today is scaling an infrastructure that can provide quality of service (QoS) to a wide variety of applications and traffic types.

3. METHODOLOGY

This section explains the technique and tools that are used for the analysis. The flowchart and activities explain in detail the desired deliverables.

3.1 Research Framework

Research framework has been planned that take the actions to analyze the traffic performances. Figure 2 presents the research framework that shows the steps from data collection, data analysis, performance comparison analysis and documentation.

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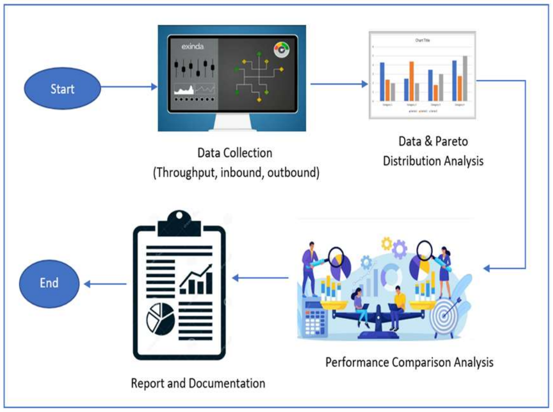

Figure 3: Research Framework

3.2 Metro-E Network Architecture

Metropolitan area networks are at the confluence of business and home users and connecting enterprises to core networks and residential users to the rest of the Internet. This important segment of the network spans cities, regions, districts and municipalities and is a prime driver segment of broadband networking as well as being pivotal in providing connectivity to enterprises. Metropolitan optical networks are undergoing significant transformations to continue being able to provide services that meet the requirements of the applications of the future[23]. Metro Ethernet technology is one of the developments of Ethernet technology that can cover large distances on an urban scale, equipped with various features found in Ethernet networks in general. To create a metro-scale network utilizing standard Ethernet technology, the Metro Ethernet network leverages the Ethernet protocol as a Metropolitan Area Network (MAN) in the same manner that a Local Area Network (LAN) uses the protocol[24]. Metro Ethernet acts as a bridge or bridge of a network connecting separate regions and connecting LANs and WANs or backbone networks that are generally owned by service providers. Figure 3 shows a design of Metropolitan Ethernet networks (MEN), which were implemented in a metropolitan area using earlier Ethernet standards. In the enterprise metro network, Metro Ethernet is the prevailing technology. Ethernet switches and edge routers are the fundamental elements of metro Ethernet.

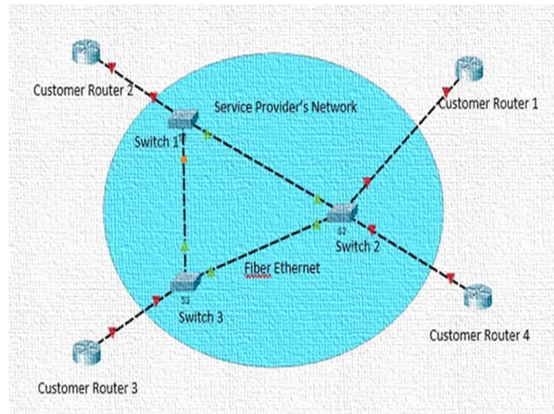

Figure 3: Metro-E Network Diagram

3.2 Activities Flow

Activities flow in data analysis is an important thing to make sure the flow of the activities will be going smoothly. Figure 4 presents the flowchart of this research from the beginning until the end of the activities.

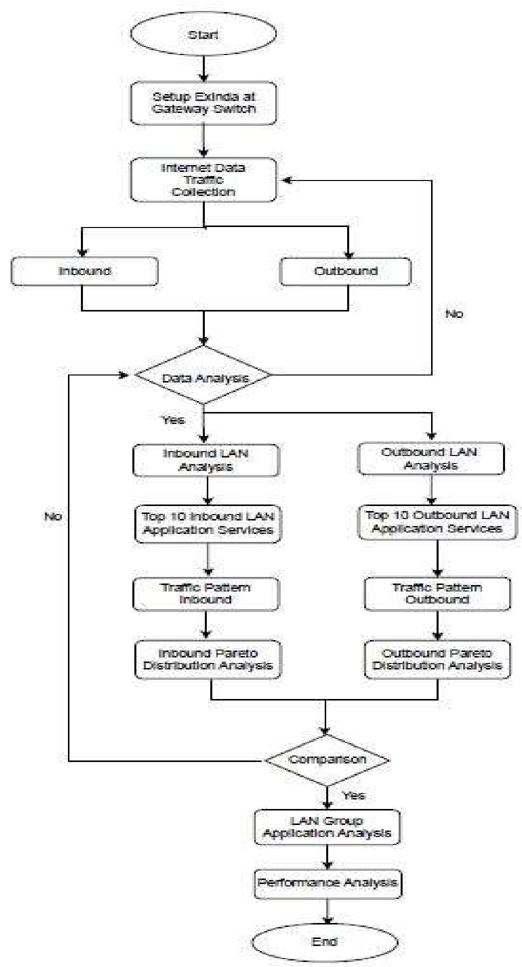

Figure. 4: Activities Flow

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A Gateway Switch will be equipped with Exinda Network Orchestrator as a network monitoring system for data collection. LAN internet traffic data will be collected every 10 seconds inter-arrival time and will be summarized into 1 hour per month. Internet traffic data were collected for six months starting from 1st February 2022 until 31st August 2022. To characterize the internet traffic, a statistical analysis approach and Pareto distribution will be used. The comparison analysis of inbound and outbound LAN, top 10 inbound and outbound LAN application services and inbound and outbound traffic patterns were made including an analysis of LAN group application. A result of the performance analysis for both inbound and outbound internet LAN Metro-E network traffic will be used for QoS bandwidth management.

3.3 Exinda Monitoring Tools

For bandwidth monitoring, LAN optimization, and traffic shaping, a few network monitoring applications are utilized. Network monitoring can receive real-time management information from some monitoring systems, such as the Exinda SD-WAN. Whereas, the Exinda Network Orchestrator has been designed to analyze the performance of specific applications and/or to collect data for further analysis. Exinda is a tool that provides controlling the bandwidth of the computer equipment that is connected to the network, and it manages monitoring the network. Users can view and analyze their performance on the network and in the application by implementing network optimization with the Exinda appliance[25]. A difficult and challenging responsibility for network managers is capturing every network traffic, and monitoring and analyzing online activities[26].

3.4 Data Collection

Six months of LAN Metro-E campus network packet and throughput data was collected. Data was collected start from 1st February 2022 until 31st August 2022. Exinda Network Orchestrator was used to gather data for LAN Metro-E, which was then collated into a table and plotted on a Pareto distribution graph for further analysis. The Pareto distribution is most used to represent self-similar internet traffic and this distribution is defined by a location and a shape parameter. The generation of self-similar traffic in multiservice IP networks, where heavy-tail distributions are devoted, is best described by this distribution. Self-similar traffic models are widely used to describe traffic in packet-switched networks[27].

4. RESULT AND DISCUSSION

In the process of building optimal network performance, the results of the analysis of the use of internet applications by users on the Metro-E LAN are very necessary. All data includes incoming and outgoing applications, application groups and URLs data transfers from the Metro-E LAN campus network. The result will be a guide in determining bandwidth management and QoS Internet promising to meet the needs of the campus network. To evaluate the design of a network system that is more effective at managing bandwidth to satisfy user needs, the results of the analysis of the six months of data will be used.

4.1 LAN Inbound Application Analysis

Data throughput for LAN application inbound and outbound was taken for 6 months starting 1st February 2022 until 31st August 2022. Figure 5 shows the Top 10 throughput summary for inbound Applications on the LAN Metro-E network. The inbound throughput was captured for the different days in six months. The campus network provides the highest bandwidth to fulfill all students' and educational staff's needs[28]. Traffic reach is quite high for some applications that are inbound where the maximum throughput reaches up to 1608.1Mbps for certain applications on weekdays compared to weekends.

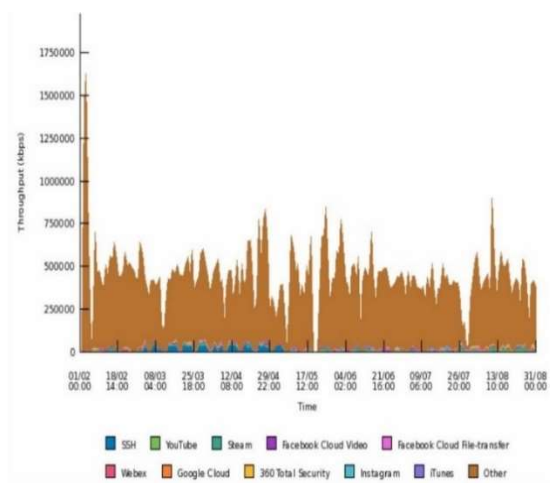

Figure 5: Top 10 Throughput Summary Inbound Application LAN

The inbound application is comprised of traffic generated from various application sites. Table 1 presents the monitored top 10 internet applications with total data on inbound throughput is 28.118424TB. The top 3 protocol apps on the LAN network were found to be Others, YouTube, and Steam, and they accounted for 70.82%, 20.88%, and

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1.94% of all inbound applications, respectively. There are many reasons why many people use YouTube, ranging from personal enjoyment to seeking knowledge and even socializing with other users[29]. Today's young people, especially students, discover new technologies and applications like virtual reality (VR), augmented reality (AR), context-based information, tactile Internet, and cloud gaming services to be increasingly attractive.

Table 1: Top 10 Inbound Application LAN

Apps	Inbound LAN			
	Total Data (MB)	Throughput		
		MAX (Mbps)	Thro AVG (Mbps)	%
Others	19915591	1608.1	9.164	70.82%
YouTube	5869981	13.6	2.701	20.88%
Steam	546350	39.1	0.251	1.94%
Facebook Cloud File-transfer	491074	11.9	0.226	1.74%
Facebook Cloud Video	482345	9.6	0.222	1.72%
Instagram	297645	3.7	0.137	1.05%
Google Cloud	256884	16.5	0.118	0.91%
Webex	119542	15.6	0.055	0.42%
iTunes	112156	12.5	0.052	0.39%
SSH	19526	43.9	0.009	0.07%
360 Total Security	7330	25.5	0.003	0.02%
TOTAL	**28118424**	**1800**	**12.94**	

Figure 6 shows a relatively high amount of data downloaded, especially streaming applications, games, and instant messaging. The Pareto distribution model was identified for the inbound data collection. The highest data is an application under Others. This application includes Google Play, Google Drives, and private TCP port 902. Some users are identified as using internet applications like YouTube, TikTok, and Facebook regularly where these websites present a bigger number of network packets. TikTok is the fastest-growing application today, attracting huge active users and audiences, mostly children and teenagers[30]. An analysis by online data providers SimilarWeb and Apptopia reveals that websites used Facebook, Netflix, and YouTube more frequently than mobile apps.

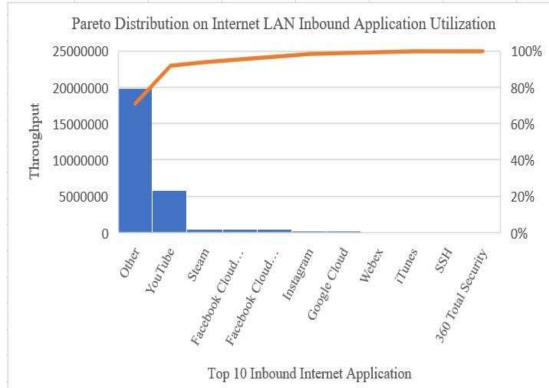

Figure 6: Pareto Distribution on Internet LAN Inbound Application Utilization

4.2 Outbound Application Analysis

The maximum bits per second that a network element can transfer or download is known as outbound traffic. To ensure that all applications make use of the allocated bandwidth, outbound application utilization is analyzed for QoS in network services. Limiting bandwidth for some applications, ensuring minimum bandwidth for others, and designating traffic with high or low priorities are all necessary for managing and controlling network traffic. Indirectly all access to the application can be implemented. Figure 7 shows the highest throughput on working days up to 314.13Mbps.

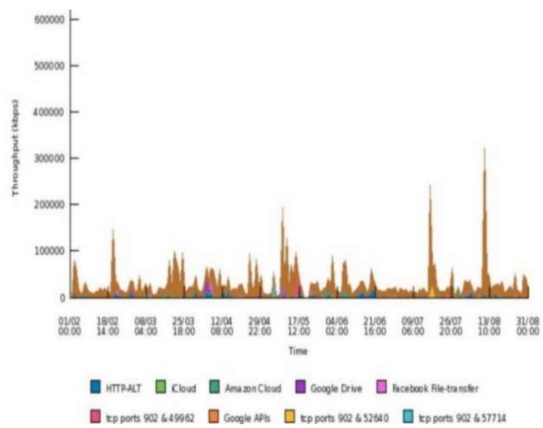

Figure 7: Top 10 Outbound Application LAN

Table 2 shows the capture of the top 10 outbound internet applications which are Others, iCloud, TCP port 902 & 52640 and Amazon Cloud was the outbound application with the highest total data submitted. Most of the outbound bandwidth is consumed by the student and lecturers thru uploading documents or accessing the cloud.

Table 2: Top 10 Outbound Internet Applications

Apps	Outbound LAN			
	Total Data (MB)	Throughput		
		MAX (Mbps)	AVG (Mbps)	Percentage %
Others	1735089	314.1	0.798	82.86%
iCloud	117886	13.2	0.054	5.63%
TCP ports 902 & 52640	106830	27.4	0.049	5.10%
Amazon Cloud	77586	18.3	0.036	3.71%
Google Drive	40041	31.2	0.018	1.91%
HTTP-ALT	7643	20.3	0.004	0.37%
TCP ports 902 & 57714	2225	40.7	0.001	0.11%
TCP ports 902 & 49962	2136	41.0	0.001	0.10%
TCP ports 902 & 50807	2136	40.7	0.001	0.10%
Google APIs	1352	5.4	0.062	0.06%
Facebook File-transfer	860	31.0	0.000	0.04%
TOTAL	**2093784**	**583.3**	**1.024**	

Figure 8 presents that the Pareto distribution model was identified on outbound LAN application utilization. Based on the Pareto distribution shows that the others application comes with the highest throughput and 82.86% of total outbound bandwidth while the iCloud application used 5.63% of total outbound bandwidth.

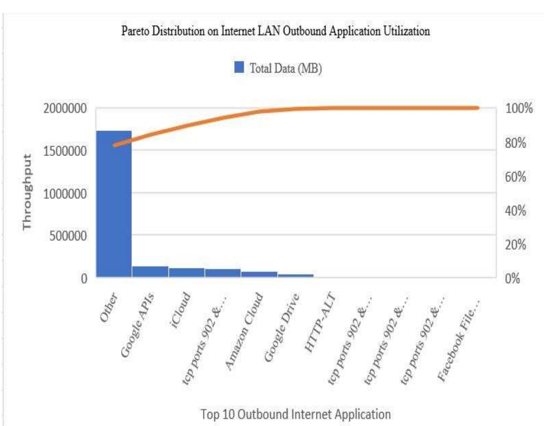

Figure 8 Pareto Distribution on Internet LAN Outbound Application Utilization

4.3 Internet Application Group Traffic Analysis

An analysis of applications based on the group of applications classified on LAN Metro-E was analysed. Figure 9 and Figure 10 shows traffic pattern changes for an inbound and outbound specific group of application. Traffic pattern changes based on inbound and outbound traffic volumes, reduced traffic asymmetry, significant growth in online video conferencing and VPN traffic, structural changes in workday traffic patterns and more global distribution of campus network users. Even though the internet and speed have substantially increased over the past decade to an acceptable level, a poor internet connection can drastically affect cloud-based education and e-learning.

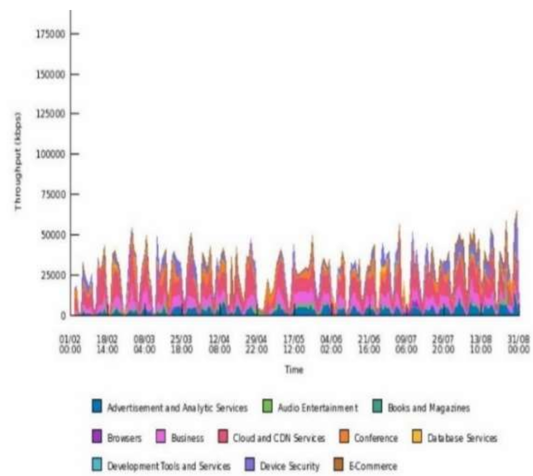

Figure 9: Traffic Pattern for Inbound Group of Application

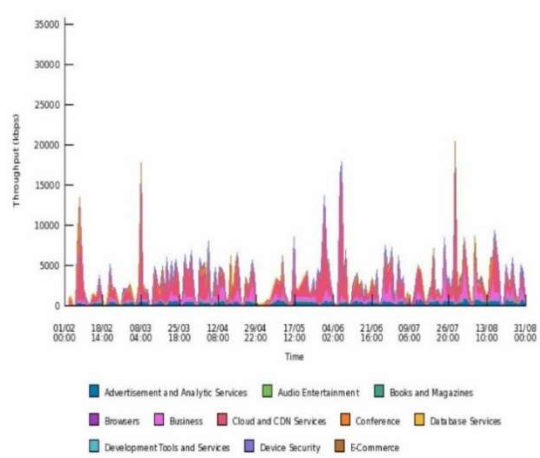

Figure 10: Traffic Pattern for Outbound Group of Application

Table 3 shows the capture of the total data for the inbound and outbound LAN groups of the application's internet traffic. Cloud and CDN Services was the group of applications with the highest total data submitted where 1579019MB for inbound and 226006MB for outbound. Cloud-based CDN (CCDN) has received widespread attention due to its flexibility and high scalability. YouTube, TikTok and Netflix highly rely on CDN (content delivery network) for content distribution to provide end-users with high-quality content-related services.

Table 3: Total Data for Inbound and Outbound Group of Application

Group Name	Inbound Total Data MB	Outbound Total Data MB
Advertisement and Analytic Services	61540	9026
Audio Entertainment	14449	628
Books and Magazines	119	6
Browsers	74	8
Business	838282	153783
Cloud and CDN Services	1579019	226006
Conference	312166	30952
Database Services	3996	110
Development Tools and Services	198	38
Device Security	33280	2915
E-Commerce	1000	69

Figure 11 shows a comparison of traffic pattern changes for inbound and outbound from the group of applications in LAN Metro-E. Cloud and CDN services, Conferences and Business are among the groups of applications that are often used. Facebook Cloud, Amazon, and iCloud are applications on cloud and CDN services, whereas Office 365, Cisco Services, and Google APIs are business applications. Meanwhile, application for group conference includes Webex, Zoom, Google Meet and Microsoft Teams.

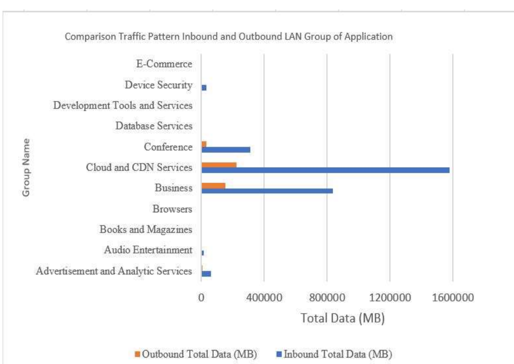

Figure 11: Comparison of Traffic Pattern Inbound and Outbound LAN Group of Application

Technologies that were used for business conferences earlier reformed themselves and emerged as the solution to bridge institutions with their students. Meanwhile, teachers are being exposed to LMS and other integrating technologies for the first time to stabilize the situation, thereby ensuring continuous learning. This application is widely used by students and lecturers for learning purposes.

4.4 URLs Data Transfer

Figure 12 and Figure 13 show URLS data transfer among inbound and outbound throughput on LAN Metro-E. To improve staff and student use of internet applications, the campus LAN network has increased capacity. Access to current online information sources, the availability of multimedia resources, and content that is not constrained by distance or time are some of the advantages of the internet for academics. High data transfer on download and gaming websites is presented in the graph.

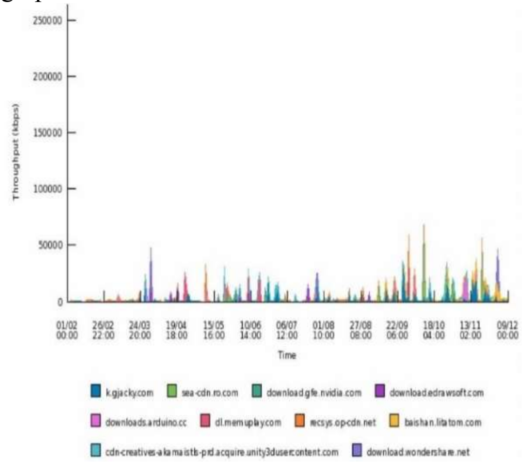

Figure 12: URLs Inbound Data Transfer

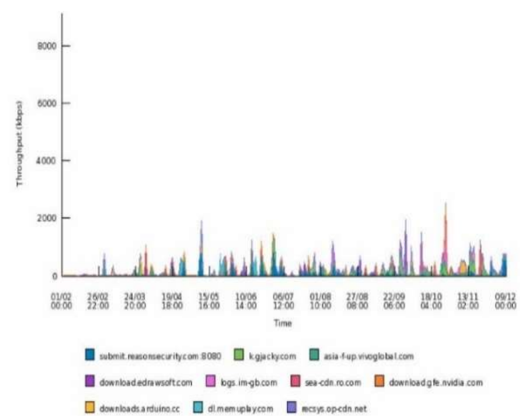

Figure 13: URLs Outbound Data Transfer

As we can see in Table 4, the URL that uses the highest total data is k.gjacky.com where this URLS used a total of 41531.13MB for inbound and 947.631MB for outbound data transfer. It shows that users go to non-educational websites such as online gaming applications and social media during classes or working days. Social media was often used as a supporting resource to help a student understand a lesson. However, social media content, especially posts about the academic success of their friends and motivational quotes, gave them more motivation to study hard and obtain academic achievement. [31].

Comparison of this study with recent previous work related to accelerated resource allocation based on experience for B5G networks and bandwidth-aware multi-interface scheduling and delay-constrained gateway-to-device communications in IoT which shown some similar impact for bandwidth and resource management is reviewed in 2023 [32, 33]. Thus, this research presents it novelty based on recent performance collected from the live time on metro-E Network in a Campus in Malaysia.

Table 4: Top 10 URL LAN

URLs Name (Inbound)	Total Data (MB)	URLs Name (Outbound)	Total Data (MB)
k.gjacky.com	41531.13	k.gjacky.com	947.631
sea-cdn.ro.com	12200.14	sea-cdn.ro.com	256.087
download.gfe.nvidia.com	5245.67	download.gfe.nvidia.com	120.417
download.edrawsoft.com	8900.58	download.edrawsoft.com	303.852
downloads.arduino.cc	1042.05	downloads.arduino.cc	26.700
dl.memuplay.com	14751.39	dl.memuplay.com	441.266
recsys.op-cdn.net	159.76	recsys.op-cdn.net	5.729
baishan.litatom.com	159.76	asia-f-up.vivoglobal.com	60.663
cdn-creatives-akamaistls-prd.acquire.unity3dusercontent.com	222.68	submit.reasonsecurity.com:8080	98.063
download.wondershare.net	1351.40	logs.im-gb.com	28.954

5. CONCLUSION

The data packet and throughput in inbound and outbound traffic on the LAN internet Metro-E network have been successfully analysed in this research. Internet application services were identified based on the top 10 applications, application group traffic analysis, and URL data transfer. Based on the fitting analysis of the inbound and outbound traffic, the Pareto distribution model was identified. Video-sharing apps and cloud computing services have shown the highest percentage of bandwidth utilization in the network, based on the percentage of application usage. Top URL LAN also has been identified and analysis presents that some URLs are useful for academic purposes. The group applications utilization also shows applications like conferences, cloud and CDN services, and business-related internet communication, all of which demonstrate the productive activity on the campus network. Based on the analysis that has been done, the LAN Metro-E network show internet campus activities run effectively but improvements must be made, especially in bandwidth utilization. The limitation of this research is data collected from one campus network only at a support leased line of 100Mbps which is a small gateway. Different network may find difference performance, but internet traffic model may present some similarity. Future works maybe done to compare the descriptive statistical analysis and traffic modelling for the live time data collected on the metro-E network.

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