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# The University of Lampung Internet Traffic Measurement: Trends and Impact in Campus Network

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***Abstract*— University of Lampung (Unila) is an Institution of Higher Education located in Bandar Lampung. Since 2016, Unila has deployed Internet Access Management (IAM) to guarantee the healthiness of the campus network, as well as to enhance the effectiveness of the bandwidth usage.**

**This study focused on internet traffic measurement, conducted in Unila's campus network during February 1 until February 29, 2016. Overall, this study shows user behavior on their application. The trend data of monthly most popular URL Categories accessed by users was; 1st Computers & Technology with 30032328 hits or 39.1%, the 2nd was Search Engines & Portals with 14214611 hits or 18.5%. There were around 30-40 % of internet traffic was use for Streaming Media activity, it proves that the existence of Streaming Media Activity in Campus Network which contribute to network congestion. During a month doing internet measurement, we identify the most active device/user that are the 1st was Aruba Wireless Controller with total traffic flow 40.45%, the 2nd was CCR-1 with 26.2%, the 3rd was CCR-2 with 16.9%, and the 4th was Digital Library Server with total flow was 0.6%. Monthly uplink traffic total flow was 5889.92 GB while downlink traffic total flow was 61041.35 GB.**

**We made a recommendation to Unila management for implementing traffic provisioning especially on streaming media activity specific on access to Google Global Cache (GGC), to overcome network congestion during peak time period on working hours.**

***Keywords*— *internet access management; internet traffic measurement; traffic trend***

## I. INTRODUCTION

University of Lampung (Unila) is an Institution of Higher Education located in Bandar Lampung - the provincial capital of Lampung, Indonesia. Established in September 13, 1965. Unila has deployed Internet Access Management to guarantee the healthiness of the campus network, as well as to enhance the effectiveness of the bandwidth.

Unila has around 6.000 concurrent online users used internet peak time from almost 27.000 of total Academia Civitas, which brings the difficulty to manage the campus network.

As an academic area, the University wants to conducting internet traffic measurements to understand the performance of networks, for troubleshooting needs, to figure out where the faults are, concerned about ensuring the security of networks, also to check whether internet operators are in compliance with the Service Level Agreements (SLA), and to make decisions of how to invest for the deployment of the future Internet infrastructure.

Since February 2016, UNILA already developed Internet Access Management (IAM) using SANGFOR™ system, to provide an integrated solution to monitor, manage and accelerate the Unila's network. IAM can identify and categorize the Internet resources by comprehensive reports, so Administrator capable to visualize the Internet usage status and filter the non-work related websites and applications.

It is very important to isolate the students from the disruptive Internet content such as pornography, violence and gambling. In addition, young students use P2P download softwares and video streaming actively should be warned, which consumes loads of bandwidth and causes network congestion to other critical applications.

This paper presents an internet traffic measurement of Unila campus network, traffic statistics, website browsing statistics, p2p activity, most active users, and application flow speed trend comparison. We collect the internet activity data since February 1, 2016 until February 29, 2016 (a month) on Campus networks. The aims of the internet measurement analysis are (1) To classify the type of application that affects the network performance (2) To analyze user behavior based in type of application . Section 2 describes the several literature review on internet measurement. Section 3 introduces the technique and monitoring tools that used in this study. Section 4 discusses on analysis of result. Finally the conclusion of this work is described in Section 5

## II. Related Works

Network traffic measurement provides an Administrator network to understand the traffic flow behavior in term of throughput, latency, speed, and packet data transmission. By using specialized network measurement hardware or software, online or offline measurement, an administrator network can collect more information about packets transmission on their network [1] [2]. Based on research of internet user behavior by a group of researcher from Lund University, Sweden, they categorized application into 7 categories that are [3] web browsing, multimedia streaming, Peer to Peer (P2P), file transfer, game online, messaging and collaboration, and secure session. The network administrator should know exactly which applications/users are consuming the most of network bandwidth resource [4]. A study on mature of IEEE 802.11 WLAN campus at Darmouth College, USA found that the applications used on the WLAN changed affectedly. Initial WLAN usage was majoring by Web Traffic; but the study shows significant increases especially in P2P, streaming multimedia, and voice over IP (VoIP) traffic [5]. An increase in the percentage of P2P traffic and multimedia and inconsistent trend for Web traffic can be explained by the increasing complexity and overall size of Web pages that include more audio, images and video elements [6]. Nowadays network operator are faced with rapidly growing of video traffic that cause a main source of congestion in their networks. In order to reduce congestion, N. Khan, on their work [7], timely video rate adaptation is required at the Radio Access Network (RAN)

Aaron et al on their works paper [8], has made a deep packet trace analysis of two wireless network environment that place separately and still parts of campus network, with total observation time was for 3 days to gathering the data traffic for total 32,278 unique device. They get the trends of handhelds usage device connected to Wireless including UDP data transactions, also HTTP protocol with high traffic volume transactions, and video traffic. Security performance in wireless LAN already shown on works [9] [10] [11] [12] [13] [14] [15], Poonam Jindal et al on works [9] presented their experiments result that have carried out comprehensively about the performance evaluation of network security in the 802.11 WLAN protocol. Ye Wen on works [16] describe the evaluation of wireless channel utilization at Guangdong Mobile in Guangdong province.

Gigih, et al, [17] on their research already investigate the performance analysis of Aruba™ Wireless Local Area Network at University of Lampung, on this paper explain that IT units had developed wireless infrastructure using Aruba Technology since March 2014, they introduce a wireless performance analysis based on airwave application, with 1 year of data report they gathered network activity on each Aruba AP such as usage average, clients average. On paper [18] [19] [20] [21] [22] describe the usage of open source application for system monitoring. On paper [23] describe it is very important to implementing High Availability (HA) on a network.

## III. Internet Access Management Network Topology

Fig.1 shown Unila's Internet Access Management topology, on data center (DC), already installed Aruba Controller 7210 series and ClearPass System on dedicated server. Aruba Controller policy system work to manage the role of platform provides and device based network control access for Unila wireless user, and communicate with RADIUS system as Active Directory User (user profiling and also posture assessment, on boarding profile, guest access profile), and a comprehensive context-based system policy engine. ClearPass use the database user from radius server on Unila's private cloud, radius act as SSO user database backend for other academic application.

Beside Aruba Controller there is a DMZ server that monitored by IAM, the main purpose of our DMZ server is to provide another layer of security for Public Server behind DMZ system. If a rogue actor is able to gathering the access to services located in DMZ, they will not be able to get full access to the main part of the network. Some critical public server placed behind DMZ such Unila's Web Server, Mail Server, Domain Name System (DNS) server, Academic Information System, etc. DMZ also has a notification that remainder of the network to be protected if a rogue actor or hacker is able to succeed in attacking any of the servers. Any Public server that is placed behind DMZ server have limited connectivity to other hosts that solely reside within the internal network.

On Fig. 1, there also 2 Cloud Core Router that act as internet router for Faculty member, this both router installed to serve whole users connected through Campus LAN cable, we split the router into 2 router to distribute the traffic load. There were Cloud Core Router 1 (CCR1) and Cloud Core Router 2 (CCR2), CCR1 is serving total 4 Faculty, and CCR2 also serve 4 Faculty.

The end node of IAM implementation topology is Border Gateway Protocol (BGP), BGP communicate using the Transmission Control Protocol (TCP) and publish Unila's network prefix (IPv4 and IPv6 prefix) and Autonomous Number (ASN) to upstream provider, besides running BGP services the device is also act as public router for all server that placed on Data Center.

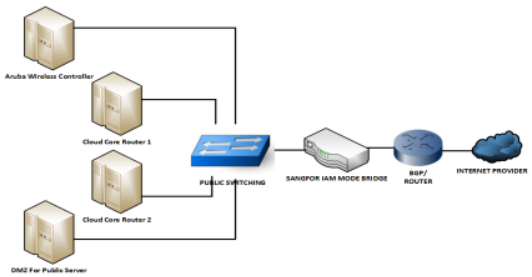


Fig 1. Unila's Internet Access Management topology.

Sangfor™ Internet Access Management (IAM) installed on Bridge mode deployment connecting between Unila's public server/routers and BGP/Public Router. We also configure IAM bridge IP or manage port IP for controlling device, whereby the

device connected to network and take over the functionality of another equipment with less or no user intervention.

## IV. INTERNET TRAFFIC MEASUREMENT ANALYSIS

### *A. Daily Internet Traffic Trend*

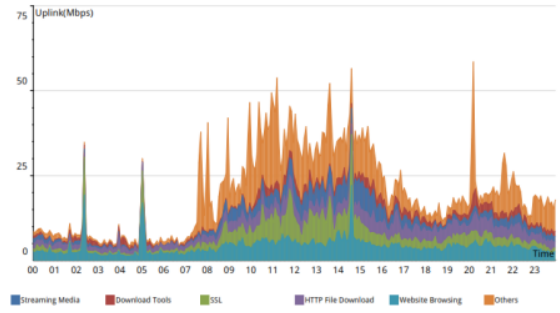


Fig 2. Daily application Uplink flow speed trend comparison overlaid graph

Fig 2. Shown the trend of daily uplink usage that was capture on February 24, 2016, as we can see the uplink traffic will start increase during the working hours (08.00-16.00). The peak time held on 11.00 AM until 3 PM.

TABLE I. DAILY OUTBOUND APP DISTRIBUTION

| | Application | Peak Rate | Avg. Rate | Total Flow | Percent |
|---|---|---|---|---|---|
| 1 | Streaming Media | 8.35Mb/s | 2.26Mb/s | 23.80GB | 11.18% |
| 2 | Download Tools | 5.03Mb/s | 1.35Mb/s | 14.22GB | 6.68% |
| 3 | SSL | 15.02Mb/s | 3.04Mb/s | 32.11GB | 15.09% |
| 4 | HTTP File Download | 7.68Mb/s | 2.85Mb/s | 30.02GB | 14.1% |
| 5 | Website Browsing | 22.10Mb/s | 4.04Mb/s | 42.61GB | 20.02% |
| 6 | Others | 39.06Mb/s | 6.65Mb/s | 70.08GB | 32.93% |
| 7 | ALL | - | 20.18Mb/s | 212.84GB | 100% |

Table I. explains the trend data of daily uplink traffic on February 24, 2016. The most consumed traffic application was streaming media, with Peak Rate **8.35 Mb/s**, Average Rate **2.26 Mb/s**, and total flow **23.80 GB** data or equal to **11.18%** from total uplink traffic.

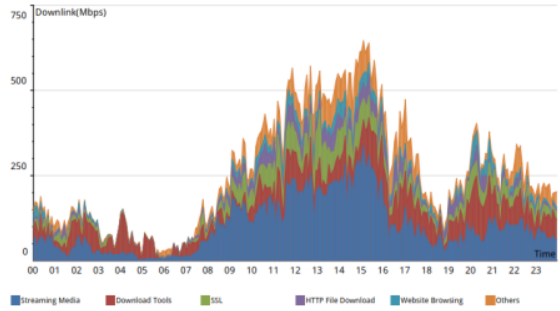


Fig 3. Daily application Downlink flow speed trend comparison overlaid graph

Fig 3. Shown the trend of daily Downlink usage that was capture on February 24, 2016, same with uplink traffic, we can see that the downlink traffic will start increase during the working hours (08.00-16.00). The peak time held on 11.00 AM until 3 PM.

TABLE II. DAILY INBOUND APP DISTRIBUTION

| | Application | Peak Rate | Avg. Rate | Total Flow | Percent |
|---|---|---|---|---|---|
| 1 | Streaming Media | 337.38Mb/s | 98.90 Mb/s | 1043.04 GB | 38.64% |
| 2 | Download Tools | 176.99Mb/s | 55.09 Mb/s | 581.04 GB | 21.53% |
| 3 | SSL | 141.29Mb/s | 31.87 Mb/s | 336.08 GB | 12.45% |
| 4 | HTTP File Download | 68.63Mb/s | 19.99 Mb/s | 210.82 GB | 7.81% |
| 5 | Website Browsing | 61.93Mb/s | 15.59 Mb/s | 164.46 GB | 6.09% |
| 6 | Others | 128.42Mb/s | 34.48 Mb/s | 363.66 GB | 13.47% |
| 7 | ALL | - | 255.92 Mb/s | 2699.11 GB | 100% |

Table II, shown the trend data of daily downlink traffic on February 24, 2016. The most consumed traffic application was streaming media, with Peak Rate **337.38 Mb/s**, Average Rate **98.90 Mb/s**, and total flow **1043.04 GB** data or equal to **38.64%** from total uplink traffic. Total flow for daily usage was **2699.11 GB**. During peak time, users frequently complain feeling difficult to access the internet [24], this happen because almost **40%** bandwidth flow was used for video streaming.

TABLE III. DAILY MOST POPULAR URL

| | Website Browsing | Application Type | Counts | Percent |
|---|---|---|---|---|
| 1 | www.google.com | Search Engines & Portals | 104960 | 3.3% |
| 2 | *.unila.ac.id | Computers & Technology | 88932 | 2.8% |
| 3 | graph.facebook.com | Social Networking | 80502 | 2.5% |
| 4 | r3---sn-2b5njvh-jb3e.googlevideo.com | Streaming Media & Downloads | 64739 | 2% |
| 5 | r1---sn-2b5njvh-jb3e.googlevideo.com | Streaming Media & Downloads | 64098 | 2% |
| 6 | r2---sn-2b5njvh-jb3e.googlevideo.com | Streaming Media & Downloads | 61264 | 1.9% |

Table III, shown the daily most popular url, search engine google was the most popular url accessed by users, the other was official Unila website, facebook, and Google Global Cache (GGC).

### *B. Monthly Internet Traffic Trend*

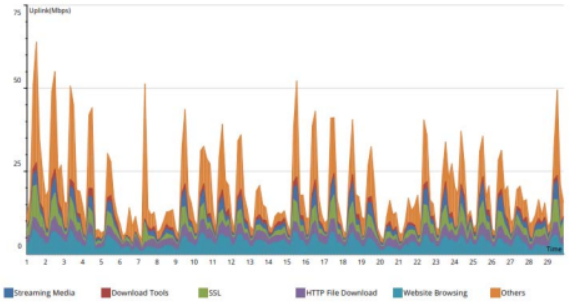


Fig. 4. Monthly application Uplink flow speed trend comparison overlaid graph

Fig 4. Shown the trend of monthly uplink usage that was capture since February 1, until February 29, 2016, as we can see the maximum uplink traffic was held on **Monday February 1**, 2016.

TABLE IV. MONTHLY OUTBOUND APP DISTRIBUTION

| | Application | Peak Rate | Avg. Rate | Total Flow | Percent |
|---|---|---|---|---|---|
| 1 | Streaming Media | 5.83Mb/s | 1.76 Mb/s | 538.06 GB | 9.14% |
| 2 | Download Tools | 2.91Mb/s | 967.07 Kb/s | 288.85 GB | 4.9% |
| 3 | SSL | 10.25Mb/ | 2.32 Mb/s | 708.86 GB | 12.04% |
| 4 | HTTP File Download | 4.55Mb/s | 2.48 Mb/s | 758.12 GB | 12.87% |
| 5 | Website Browsing | 7.67Mb/s | 3.62 Mb/s | 1106.64 GB | 18.79% |
| 6 | Others | 40.62Mb/ | 8.14 Mb/s | 2489.39 GB | 42.27% |
| 7 | ALL | - | 19.26 Mb/s | 5889.92 GB | 100% |

Table IV, shown the trend data of Monthly uplink traffic since February 1 until February 29, 2016. The most consumed traffic application was streaming media, with Peak Rate **5.83 Mb/s**, Average Rate **1.76 Mb/s**, and total flow **538.06 GB** data or equal to **9.14%** from total uplink traffic. Total flow for monthly usage was **5889.92 GB**.

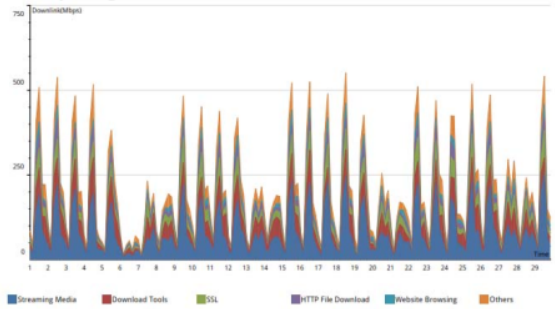


Fig. 5. Monthly application Downlink flow speed trend comparison overlaid graph

Fig 5. Shown the trend of monthly Downlink usage that was capture since February 1, until February 29, 2016, as we can see the maximum uplink traffic was held on **Thursday February 18**, 2016. At this date 6-7, 13-14, 20-21, 27-28 February shown less traffic then other day, because at this date is non-working hours (Saturday and Sunday).

TABLE V. MONTHLY INBOUND APP DISTRIBUTION

| | Application | Peak Rate | Avg. Rate | Total Flow | Percent |
|---|---|---|---|---|---|
| 1 | Streaming Media | 252.36 Mb/s | 77.80 Mb/s | 23795.59 GB | 38.98% |
| 2 | Download Tools | 104.56 Mb/s | 37.56 Mb/s | 11487.92 GB | 18.82% |
| 3 | SSL | 82.10 Mb/s | 24.67 Mb/s | 7546.62GB | 12.36% |
| 4 | HTTP File | 57.98 Mb/s | 15.45 Mb/s | 4724.54 GB | 7.74% |
| 5 | Website | 44.76 Mb/s | 12.61 Mb/s | 3857.59 GB | 6.32% |
| 6 | Others | 103.04 Mb/s | 31.48 Mb/s | 9629.08 GB | 15.77% |
| 7 | ALL | - | 199.57 Mb/s | 61041.35 GB | 100% |

Table V. shown the trend data of Monthly downlink traffic since February 1 until February 29, 2016. The most consumed traffic application was streaming media, with Peak Rate **252.36 Mb/s**, Average Rate **77.80 Mb/s**, and total flow **23795.59 GB** data or equal to **38.98%** from total uplink traffic. Total flow for monthly usage was **61041.35 GB**.

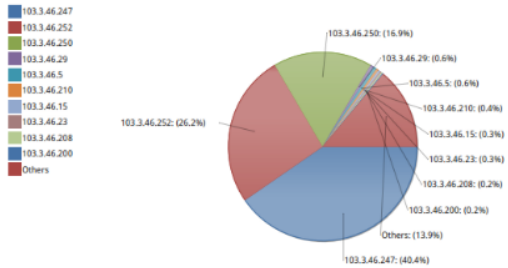


Fig. 6. Most Active Device

Fig. 6. Shown pie chart of most active device/user during February 1 until February 29, 2016. The most active device was **103.46.247** (Aruba Wireless Controller) with total flow was **27044.64 GB**, or **40.4%** from total traffic.

TABLE VI. MONTHLY INBOUND APP DISTRIBUTION

| | Host IP | Uplink | Downlink | Total Flow | Percent |
|---|---|---|---|---|---|
| 1 | 103.3.46.247 | 1449.17 GB | 25595.48 GB | 27044.64 GB | 40.4% |
| 2 | 103.3.46.252 | 1158.02 GB | 16353.58 GB | 17511.60 GB | 26.2% |
| 3 | 103.3.46.250 | 564.58 GB | 10772.40 GB | 11336.99 GB | 16.9% |
| 4 | 103.3.46.29 | 379.15 GB | 13.95 GB | 393.10 GB | 0.6% |
| 5 | 103.3.46.5 | 343.93 GB | 30.42 GB | 374.35 GB | 0.6% |
| 6 | 103.3.46.210 | 180.63 GB | 103.29 GB | 283.92 GB | 0.4% |
| 7 | 103.3.46.15 | 19.56 GB | 200.81 GB | 220.37 GB | 0.3% |
| 8 | 103.3.46.23 | 160.39 GB | 16.98 GB | 177.37 GB | 0.3% |
| 9 | 103.3.46.208 | 142.86 GB | 9.83 GB | 152.69 GB | 0.2% |
| 10 | 103.3.46.200 | 102.40 GB | 8.45 GB | 110.85 GB | 0.2% |
| 11 | Others | 1389.23 GB | 7936.17GB | 9325.40 GB | 13.9% |
| 12 | [All Users] | 5889.92 GB | 61041.35 GB | 66931.27 GB | 100% |

Table VI, shown the trend data of Monthly Inbound traffic since February 1 until February 29, 2016. The most consumed traffic device/user was Aruba Wireless Controller (**103.3.46.247**) with total flow **40.45%**, and 2nd was CCR1 (**103.3.46.252**) with **26.2%**, the 3rd was CCR2 (**103.3.46.250**) with **16.9%**, the 4th was Digital Library Server (**103.3.46.29**) with total traffic was **393.10 GB** or **0.6%**

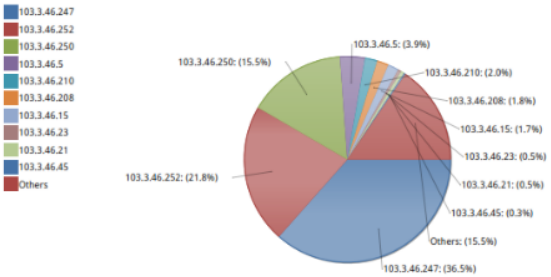


Fig. 7. User Behavior Ranking

Fig. 7. Shown pie chart of Users behavior ranking since February 1 until February 29, 2016. The most user was **103.46.247** (Aruba Wireless Controller) with total **36.5%** from total.

TABLE VII. USER BEHAVIOR RANKING

| | Host IP | Counts | Percent |
|---|---|---|---|
| 1 | 103.3.46.247 | 28058475 | 36.5% |
| 2 | 103.3.46.252 | 16809988 | 21.9% |
| 3 | 103.3.46.250 | 11938431 | 15.5% |
| 4 | 103.3.46.5 | 2966146 | 3.9% |
| 5 | 103.3.46.210 | 1498038 | 2% |
| 6 | 103.3.46.208 | 1400041 | 1.8% |
| 7 | 103.3.46.15 | 1326502 | 1.7% |
| 8 | 103.3.46.23 | 403630 | 0.5% |
| 9 | 103.3.46.21 | 379727 | 0.5% |
| 10 | 103.3.46.45 | 162409 | 0.2% |
| 11 | Others | 11869916 | 15.5% |
| 12 | [All Users] | 76813303 | 100% |

Table VII, shown the trend data of Monthly User Behavior Ranking since February 1 until February 29, 2016. The most active user/device was Aruba Wireless Controller (**103.3.46.247**), with total count **28058475** or **36.5 %,** and total count was **76813303**.

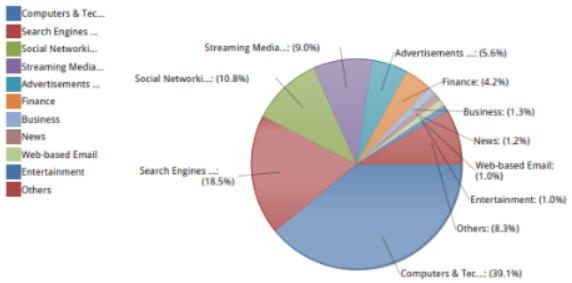


Fig. 8. Application Behavior Ranking

TABLE VIII. MOST POPULAR URL CATEGORIES

| | Application Type | Counts | Percent |
|---|---|---|---|
| 1 | Computers & Technology | 30032328 | 39.1% |
| 2 | Search Engines & Portals | 14214611 | 18.5% |
| 3 | Social Networking | 8264092 | 10.8% |
| 4 | Streaming Media & Downloads | 6893365 | 9% |
| 5 | Advertisements & Pop-Ups | 4292179 | 5.6% |
| 6 | Finance | 3154604 | 4.1% |
| 7 | Business | 1040108 | 1.4% |
| 8 | News | 946049 | 1.2% |
| 9 | Web-based Email | 828783 | 1.1% |
| 10 | Entertainment | 793993 | 1% |
| 11 | Others | 6353191 | 8.3% |
| 12 | Website Browsing | 76813303 | 100% |

Fig. 8 and Table VIII, shown the trend data of Monthly Most Popular URL Categories since February 1 until February 29, 2016. The most Application Type Category accessed by Unila's users was **Computers & Technology** with **30032328** or **39.1%**, the 2nd was **Search Engines & Portals** with **18.5%,** the 4th was **Streaming Media & Downloads** with **8264092** total count. Total website browsing hit in a month was **76813303** count.

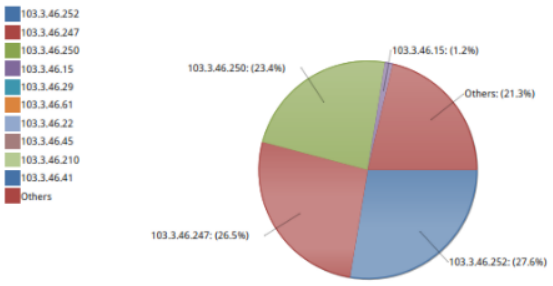


Fig. 9. User Total Flow Peer To Peer (P2P) Ranking

TABLE IX. MOST P2P ACTIVE USERS

| | Host IP | Uplink | Downlink | Total Flow | Percent |
|---|---|---|---|---|---|
| 1 | 103.3.46.252 | 377.84GB | 621.03GB | 998.87GB | 27.6% |
| 2 | 103.3.46.247 | 351.40GB | 608.10GB | 959.50GB | 26.5% |
| 3 | 103.3.46.250 | 153.35GB | 693.25GB | 846.60GB | 23.4% |
| 4 | 103.3.46.15 | 5.17GB | 36.90GB | 42.07GB | 1.2% |
| 5 | 103.3.46.29 | 2.92MB | 68.63KB | 2.99MB | 0% |
| 6 | 103.3.46.61 | 1.72MB | 795.09KB | 2.49MB | 0% |
| 7 | 103.3.46.22 | 1.70MB | 14.82KB | 1.72MB | 0% |
| 8 | 103.3.46.45 | 340.01KB | 10.84KB | 350.85KB | 0% |
| 9 | 103.3.46.210 | 301.70KB | 12.69KB | 314.39KB | 0% |
| 10 | 103.3.46.41 | 235.76KB | 6.36KB | 242.12KB | 0% |
| 11 | Others | 378.41GB | 391.44GB | 769.85GB | 21.3% |
| 12 | [All Users] | 1266.18GB | 2350.72GB | 3616.90GB | 100% |

Fig. 9 and Table IX, shown the trend data of Monthly Most P2P active users since February 1 until February 29, 2016. The 1st device was CCR1 (**103.3.46.252**) with total flow was **998.87 GB** or **27.6%,** 2nd was Aruba Wireless Controller with **959.50 GB** or **26.5%,** and the 3rd was CCR2 (**103.3.46.250**) with **846.60 GB** or **23.4%.**

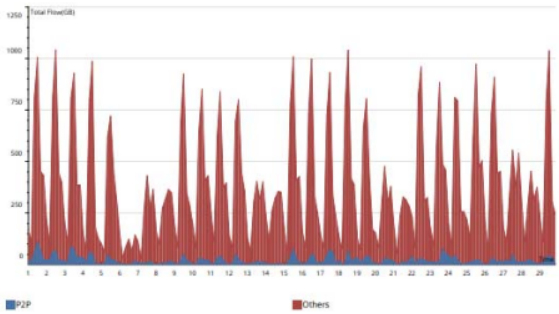


Fig. 10. P2P Application Flow Trend Overlaid Graph

TABLE X. P2P APPLICATION FLOW TREND OVERLAID

| | Application | Peak Rate | Avg. Rate | Total Flow | Percent |
|---|---|---|---|---|---|
| 1 | P2P | 63.41Mb/ | 11.83Mb/s | 3616.90 GB | 5.4% |
| 2 | Others | 566.79Mb | 207.00Mb/s | 63314.37 GB | 94.6% |
| 3 | ALL | - | 218.83Mb/s | 66931.27 GB | 100% |

Fig. 10 and Table X. shown the trend data of Monthly P2P Application Flow Trend Overlaid since February 1 until February 29, 2016. From the data we can see in a month there were total **3616.90 GB** P2P traffic or total **5.6 %** from total Flow.

## V. CONCLUSION

This study focused on Internet Traffic Measurement conducted in University of Lampung Campus Network. Overall, this study shows user (both from wireless or cable connection) behavior on the application. The trend data of Monthly Most Popular URL Categories accessed by Unila's users was Computers & Technology with 30032328 hits or **39.1%,** the 2nd was Search Engines & Portals with **14214611** hits or **18.5%** hits. There were around **30-40 %** of internet traffic flow was use for Streaming Media activity, it proves that the existence of Streaming Media Activity in Campus Network which contribute to network performance degradation. During a month doing internet measurement, we identify the most active device/user identified by Aruba Wireless Controller with total flow **40.45%,** the 2nd was CCR1 with **26.2%**, the 3rd was CCR2 with 16.9%, and the 4th was Digital Library Server with total traffic was 0.6%. Monthly uplink traffic total flow was **5889.92 GB** while downlink traffic Total flow for February, 2016 was **61041.35 GB**.

We made a recommendation to Unila management for pay a serious attention especially on Users Streaming Media Activity specific on access to Google Global Cache (GGC) to overcome network congestion during peak time period on working hours, we suggest to implement traffic provisioning of video streaming connections for improving the quality of campus network.

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