

Analysis of Wireless Network Usage at Universiti Utara Malaysia: A Preliminary Study towards Bandwidth Management

Shahida Shamsudin
UUMIT

Universiti Utara Malaysia
06010 UUM Sintok, Kedah Malaysia
+6049282321
shahida@uum.edu.my

Norliza Katuk
School of Computing

Universiti Utara Malaysia
06010 UUM Sintok, Kedah Malaysia
+6049285063
k.norliza@uum.edu.my

Kamarudin Abdullah
UUMIT

Universiti Utara Malaysia
06010 UUM Sintok, Kedah Malaysia
+6049282250
kamak@uum.edu.my

ABSTRACT

The emergent of mobile device technology has increased the need for wireless network coverage in organizations. Users with mobile devices such as smartphones, computer tablets, and laptops require a wireless network to access the Internet services. Network administrators face challenges in managing access to the Internet and data usage by these devices. The challenge can be alleviated by implementing efficient bandwidth management strategies. Before identifying the proper strategies and implement them, network administrators must understand the usage pattern of the wireless network. Hence, this study presents an analysis of traffic pattern of wireless network usage by students at Universiti Utara Malaysia (UUM) as a preliminary input towards identifying the best strategies for managing wireless network bandwidth. The students' wireless network usage on a selected student residential area in UUM was analyzed for seven days using network management software. The data on the usage of protocols, service set identifiers, and types of applications were monitored and captured. The analysis of the data suggested valuable information towards managing bandwidth at the university.

CCS Concepts

• **Networks** → **Network types** → **Wireless access networks**
→ **Wireless local area networks**; • **Network services**
→ **Network Management**

Keywords

Bandwidth management; wireless network; higher learning institutions; mobile computing

1. INTRODUCTION

The rapid advancement in mobile device technology leads to a new trend called mobile computing; where people perform their daily tasks using these devices. Mobile computing users bring their own devices to the office or public areas and require a wireless network to connect their devices to the Internet. Network

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for components of this work owned by others than ACM must be honored. Abstracting with credit is permitted. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee. Request permissions from Permissions@acm.org

HP3C-2017, March 22-24, 2017, Kuala Lumpur, Malaysia

© 2017 ACM. ISBN 978-1-4503-4868-3/17/03...\$15.00.

DOI: <http://dx.doi.org/10.1145/3069593.3069613>

administrators are currently facing challenges to manage these devices effectively in their networks [1]. One of the challenges is to provide the right amount of bandwidth in ensuring the suitable allocation of network resources to all authorized users [2].

The challenge can be alleviated by implementing a proper bandwidth management. In general, bandwidth management is a process of implementing various techniques, technologies, tools and policies to control and measure the rate of data transmission in a network [3]. It is the amount of data that can be carried from one point to another in a given period (bits per second) that running on the network layer in allocating its resources to critical applications on a network [4]. Bandwidth management is needed for network capacity to improve the performance of Internet connectivity with the most efficient use of its bandwidth resources. Otherwise, this unmanaged bandwidth will cause certain applications or users to take control of all available bandwidth and prevent others from using the network [4].

Bandwidth management is necessary for a large organization with a large number of users and area of coverage. The organizations include universities and other types of an academic institution like Universiti Utara Malaysia (UUM). UUM campus is built on an area of 1,061 hectares in Sintok, Kedah and has more than 30,000 populations of students and staff. Thanks to the wireless network technology that allows the large number of users in UUM to connect to the Internet although the campus area is very large. In UUM, the wireless network provision is managed by UUM Information Technology department (UUMIT). UUMIT is the department responsible for managing all information technology (IT) resources on the campus including the wireless network infrastructure that is known as UUMWiFi. The wireless network covers most of the buildings and areas in UUM.

In this era of the digital and borderless world, a wireless network is an important element for organizations' operations. Unfortunately, providing wireless network infrastructure for a large number of users with high bandwidth is expensive. With the increasing number of students who connect to the network, UUMIT needs an effective management of UUMWiFi so that optimal use can be achieved. Therefore, the need for effective bandwidth management strategies becomes progressively important to ensure an excellent service provision in UUM campus. In order to identify the best bandwidth management strategy, the current usage pattern must be analyzed.

This paper presents an analysis of UUMWiFi usage by the students as a preliminary work towards implementing an efficient bandwidth management strategy. Section 2 provides an overview

of the UUMWiFi network. In Section 3, the methodology for conducting the analysis is discussed and the results of the analysis are presented in Section 4. The last section concludes the work and specifies the future works.

2. UUMWiFi

UUM is the sixth Malaysian public university established on 16 February 1984. Since the beginning of its establishment, this university was set up to specialize solely in management education. At present, UUM has more than 30,000 of the student population for both undergraduate and postgraduate programs. In campus, UUM has 15 Student Residential Halls (DPP), which all together, the house of 20,000 students [5].

Global Brand Magazine has named Universiti Utara Malaysia (UUM) as the Best Eminent Management University in Malaysia for the year of 2016 [6]. In line with the current needs of wireless technology and the Internet which play a vital role in the learning, teaching and research process in university education today; UUM provides a wide coverage of 24 hours UUMWiFi service throughout the campus. It enables more than 30,000 students to gather information and communicate at anytime and anywhere within the campus. The increasing number of students and the use of electronic resources for learning, teaching, and research has caused rising of the overall bandwidth usage. Hence, the network administrators are now facing with the issue on how to maximize bandwidth utilization to fulfill the needs of the campus community.

UUM has invested in substantially more bandwidth by purchasing additional bandwidth from the Internet Service Providers (ISPs). It had increased the Internet capacity from 560 Mbps to 4 Gbps in February 2015. In future, UUM might be no longer buying more bandwidth due to the price that is expensive. Therefore, it is the responsibility of the UUMIT to look for an effective management of bandwidth to make sure an effective and optimal use of networked information resources in supporting learning, teaching and research process as the core business of a university[7].

The network administrators at UUMIT need to coordinate effort through effective bandwidth management strategy to support bandwidth utilization among students. Analysis and process of monitoring, controls, and optimization are necessary even in situations where high amounts of bandwidth are available because students keep using the Internet service and take up the available amount of bandwidth. The challenges of this problem are the technical issues of finding appropriate and effective bandwidth management techniques, and to raise awareness among students about the importance of conserving and be responsible in using bandwidth. Restriction on access to bandwidth may not be the solution to these problems since it will lead to frustration among students [7].

UUMWiFi is a free, high-speed wireless broadband network for the staff, students, and guests to access the Internet in UUM campus. Currently, UUMIT installed more than 2500 wireless access points (APs) within the academic buildings and DPPs. The wireless network operates on 2.4 GHz and 5 GHz frequency bands with Cisco Wireless Network's enhanced roaming features that allow mobile devices connected to the WiFi to move from one AP to another without losing the connection. UUMWiFi is an encrypted network that uses the latest wireless technology based on 802.1x for authentication and authorization to provide secure access. Users enjoy the unlimited volume of data when using UUMWiFi on the campus. Currently, UUMIT implements a *Fair*

Use Policy to maintain a high-quality service and give all users a fair opportunity to enjoy the network.

The policy is designed to manage and control users who are responsible for generating unreasonable large volumes of data/traffic on the network which greatly impacts the service that UUMIT offers to other users. These users often have file-sharing software or peer-to-peer/torrent apps on their notebooks, phones or tablets, and download large-format files such as music, videos and movies consistently. Users who are most likely to be affected by the Fair Use Policy are those who use peer-to-peer applications to download large files, use their mobile phone as a personal hotspot, or stream videos heavily on a daily basis. These activities use up a huge portion of network bandwidth, affecting other users.

The UUMIT Fair Use Policy enforces the following rules:

- a) The UUMIT reserves the right to monitor and control service usage and/or types of traffic transmitted on the network. User access to bandwidth and network resources will be controlled to provide the best possible Internet experience to all users.
- (b) The UUMIT will advise the users if the individual UUMWiFi usage exceeds the estimated use patterns or is inconsistent with normal usage patterns.
- (c) UUMIT will request the users to stop or alter their usage to come within our Fair Use Policy.
- (d) UUMIT will suspend or restrict access to UUMWiFi without further notice if the excessive or unreasonable usage continues after receipt of such request.

Staff and students in UUM can check their monthly WiFi usage by login to the UUMWiFi Selfcare. Figure 1 shows the user interface of UUMWiFi Selfcare which stated the individual data usage on a monthly basis.

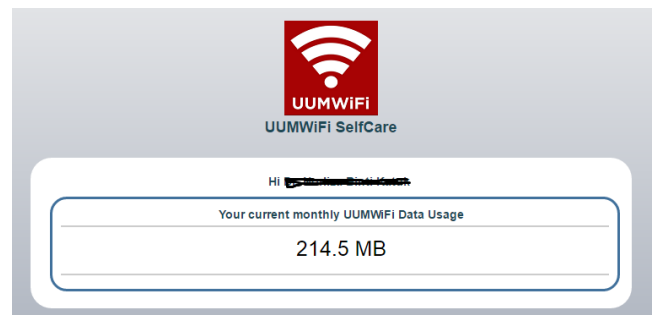


Figure 1. The Interface of UUMWiFi Selfcare System

In order to ensure the integrity and appropriate use of the university's network, ICT Policy has been applied to all members of the UUM community or visitors who have any device connected to the campus network. Policy rules about Internet Usability can be referred in Section 6.4 of the university's ICT policy book. Further, policy rules about User Accessibility can be referred in Section 8.7 of the same book [8]. The university believes that compliance with the policies and guidelines provided will reduce service problems for everyone and provide a more robust campus infrastructure.

3. METHODOLOGY

The aim of this paper is to present the analysis of the UUMWiFi usage by the students. The UUMWiFi network activities were monitored using integrated Cisco network management tools. The tools report the usage patterns and traffic trends on real time data

or within a selected period (day, week, month, and year). With such statistics, the network administrators can analyze the valuable information on how bandwidth is used in the network including information on the users, devices, protocols, access points, destinations, applications, bandwidth usage per user, total overall bandwidth usage, and more.

In the first step, bandwidth usage statistics of all user sessions were captured and logged during the first week of December 2015 by using Cisco Wireless Access Points, Cisco Prime Network Control System (NCS) and Cisco Identity Services Engine (ISE) as controllers and management tools. Monitoring involved on APs at the DPP areas. Table 1 shows the network monitoring setting.

Table 1. Information on the network monitoring setting

Type of AP	Cisco 1702i
Number of APs	843
Number of Students	8765

During the study, there are three service set identifiers (SSIDs) used by UUM communities to access the wireless network on campus named UUMWiFi, UUMWiFi_Temp and UUMWiFi_Guest. Table 2 shows the description of the SSIDs.

Table 2. Description of the SSIDs

SSIDs	Description
UUMWiFi	An Authenticated wireless network for students and staff.
UUMWiFi_Temp	A temporary and unauthenticated wireless network for staff, students, and guests that is setup during the monitoring period.
UUMWiFi_Guest	An unauthenticated wireless network for university’s guests.

These research activities begin with configuring WLAN SSID profile named UUMWiFi for certain access points in student residential area. Network traffic data in this area were chosen as sample data in the corresponding bandwidth activities. All data were logged and captured by using the tools during 7 days monitoring period and analyzed to identify the UUMWiFi’s usage pattern by the students.

The statistics enabled the calculation of total bandwidth consumed by each user in each period according to different types of analysis such as traffic analysis, protocol analysis, and user session analysis. Information about the individual users were also collected including user ID, MAC address, user IP address, access point nodes and the timestamp during session initialization. However, information on individual users is not reported in this paper as we consider this as confidential.

4. ANALYSIS OF UUMWiFi USAGE

The analysis shows that UUMWiFi used IEEE 802.11n (2.4 GHz), 802.11n (5 GHz), 802.11g; 802.11ac, 802.11a and 802.3 standards. The highest access protocol used is 802.11n (2.4GHz) with 57.55% connections, and a average number of clients is 25408. The pie chart in Figure 2 shows the maximum number of clients based on

the protocols used. The information on the average number of session, average number of clients, the total session time and the total traffic in GB are shown in Table 3.

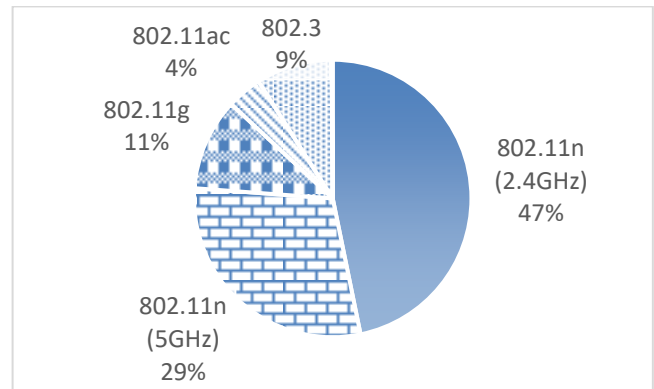


Figure 2. The percentage of clients based on the protocols

Table 3. Summary of session, clients and traffic based on Protocols

Protocols	Average number of Sessions	Average Number of Clients	Total Session Time (Hours)	Total Traffic (GB)
802.11n (2.4GHz)	135770	25408	4320085.68	76285.81
802.11n (5GHz)	18868	5808	604084.15	7488.42
802.11g	12285	5826	413964.17	2948.01
802.11ac	7380	2229	213006.23	3384.84
802.3	5690	4806	552640.8	1.07
802.11a	134	70	5140.32	103.96

Users’ access to UUMWiFi_Guest is 41.91%, UUMWiFi_Temp is 40.3%, and UUMWiFi is 17.26%. The bar chart in Figure 3 shows the number of clients based on the SSIDs. It shows that users are more likely to get connected to UUMWiFi_Guest and UUMWiFi_Temp which both SSIDs were configured without authentication enforcement policy. The summary of the session, clients and traffic based on SSIDs is rendered in Table 4.

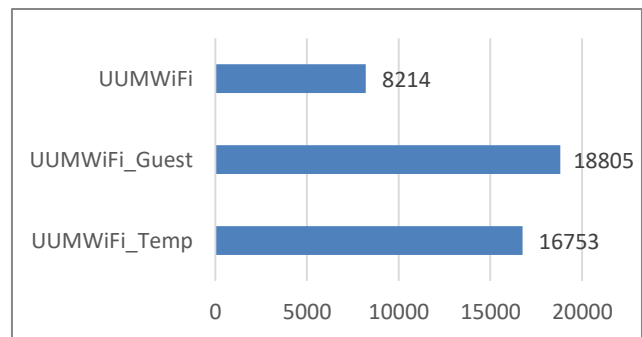


Figure 3. Number of clients based on SSIDs

Access to UUMWiFi_Guest and UUMWiFi_Temp is easier because users do not have to provide username and password for authentication. Even the percentage of clients' access to UUMWiFi_Guest is the highest which is 41.91%, but the network traffic percentage is the lowest due to the speed of 1Mbps that has been configured to this SSID. The top ten most active hosts come from the Internet Protocol (IP) address range 10.19.x.x which is specified for UUMWiFi_Temp. UUMWiFi_Temp is not configured with limit access policy.

Table 4. Summary of session, clients, and traffic based on SSIDs

Protocol	Average number of Sessions	Average Number of Clients	Total Session Time (Hours)	Total Traffic (GB)
UUMWiFi_Temp	83866	16136	2570130.53	67693.29
UUMWiFi_Guest	64584	16780	1976050.53	8872.39
UUMWiFi	25476	6911	984197.97	13127.99

The study also analyzed the types of application that students frequently accessed. Email, file transfer, instant messaging and voice over IP through Secure Socket Layer (SSL) and secure hypertext transfer protocol (HTTPS) were the most frequently accessed applications by the students. Students consumed large amounts of bandwidth for accessing peer-to-peer application such as BitTorrent, Thunder, and eMule. Table 5 shows the packet and byte count for the protocols and applications used by the students including Facebook, Google Drive, download manager and other social media and streaming sites.

Table 5. The packet and byte count for the top applications accessed by the students

Applications Name	Packet Count	Byte Count
SSL	245905	336.42MB
Secure-HTTP	128501	162.49 MB
Video-over-HTTP	98739	136.30 MB
HTTP	83243	103.26 MB
Google-services	77891	98.80 MB
Facebook	74489	85.81 MB

The study also analyzed the top ten most active hosts. They used the Internet Protocol (IP) addresses ranged within 10.19.x.x which were specified for UUMWiFi_Temp. UUMWiFi_Temp is not configured with bandwidth limit access policy. Therefore, the usage of bandwidth has become uncontrolled. Some users utilized all available bandwidth that prevented others from using the network. Users preferred to use this SSID as they thought that it is

much easier to access to UUMWiFi_Guest and UUMWiFi_Temp because they can access the WiFi more quickly without the need to configure their device by key in Username and Password. Once users have experienced the convenience and freedom of accessing WiFi without authentication, they will feel uncomfortable to set up their device with request approval before connecting to WiFi service. UUMWiFi_Guest is provided to University's guest; hence, UUM campus community, especially students should not connect to this SSID in the first place.

Analysis presented in this section suggested that students accessed the Internet in unsafe manner (i.e., authentication credentials are being ignored). Further, unlimited bandwidth usage through applications that consuming large amounts of bandwidth (i.e., BitTorrent, Thunder, eMule or other P2P tools) has become a major needs for implementation of proper management of the network practices and traffic policies.

Based on the findings of this study, there are two aspects of network usage that the UUMIT identified as important. First, the urgent need for implementation of bandwidth management strategies and the need for educating users in terms of their awareness towards a secure network usage and responsibility of using the network resources for ethical usage.

As many contents are available in the electronic form and online, the provision of high-speed Internet connection is necessary for a university [9-10]. Further, students in the university are now highly depending on their mobile devices (smartphones and tablets) to communicate and learn. Consequently, the number of mobile devices in the network increases and creates a great challenge to network administrators to manage them [1]. In order to maintain a high quality of Internet service provision, bandwidth management must be implemented soon in UUM. It involves with managing or allocating bandwidth effectively and efficiently to devices in the network [11-12]. Imposing a quota to each device in the network could be one of the approach to the bandwidth management [13]. There are many network hardware and software that can be used to achieve this task.

5. CONCLUSION

This paper presented an analysis of wireless network usage by students at UUM. The results act as a preliminary input towards identifying the best strategies for managing wireless network bandwidth. The students' wireless network usage on a selected student residential area in UUM was analyzed for seven days using network management software. The data on the usage of protocols, service set identifiers, and types of applications were monitored and captured.

The results of the study revealed that 802.11n (2.4GHz) was the top protocol used by the students. Further, the students used UUMWiFi_Temp more frequent than the authenticated UUMWiFi network. The analysis also found that students accessed to P2P applications such as downloading movies that could not be necessary for their academic purpose.

Ideally, bandwidth usage and its impact on the network performance of university should also include the staff, lecturers, and researchers. Hence, in we plan to conduct a thorough analysis for all users and applications in UUM. Apart from that, user awareness is the fundamental step and must be set as an on-going process towards effective bandwidth management. Users especially students use the Internet in many different ways in their daily activities. However, not all of these activities are having much academic worth. The university must educate them to use

the network wisely, to understand the impact of bandwidth consumption on tuition fees, and the need for accountability in the use of the Internet.

6. REFERENCES

- [1] Wei, X., Valler, N.C., Madhyastha, H. V., Neamtiu, I. and Faloutsos, M. 2017. Characterizing the behavior of handheld devices and its implications. *Computer Networks*, 114, 1-12. DOI= <http://dx.doi.org/10.1016/j.comnet.2017.01.003>
- [2] Sharma, V., Kumar, V. and Thakiu, B. 2011. Need of bandwidth management and formulation of policy framework for effective utilisation of Internet services within a university campus. *International Journal of Computer Science and Communication*, 2,1, 173-178.
- [3] Snehalatha, N., Julia, S.A. and Rodrigues, P. 2013. Survey of Bandwidth Management Techniques. *International Journal of Science and Modern Engineering (IJISME)*, 1,8, 12-15.
- [4] Kassim, M., Ismail, M., Jumari, K. and Yusof, M.I. 2012. September. Bandwidth gain analysis for HTTP and HTTPs traffic on IP based network. In *2012 IEEE Symposium on Wireless Technology and Applications (ISWTA)*, 303-308. DOI = 10.1109/ISWTA.2012.6373866
- [5] UUM. *The Official Portal of Universiti Utara Malaysia*. 2016 [cited 2016 28 December]; Available from: <http://www.uum.edu.my/index.php/en/aboutuum>.
- [6] Global Brand Magazine, *Universiti Utara Malaysia named the Best Eminent Management University in Malaysia by Global Brands Magazine for the Year 2016*. 2016; Available from: <http://www.globalbrandsmagazine.com/universiti-utara-malaysia-named-the-best-eminent-management-university-in-malaysia-by-global-brands-magazine-for-the-year-2016/>.
- [7] Hamza, A. and Noordin, M.F 2013. BYOD usage by postgraduate students of International Islamic University Malaysia: An analysis. *International Journal of Engineering Science Invention*, 2, 4, 14-20.
- [8] UUMIT. *Dasar Teknologi Maklumat dan Komunikasi, Universiti Utara Malaysia*. 2016; Available from: http://it.uum.edu.my/images/stories/documents/DASAR_IC_T_UUM_versi2.0.pdf.
- [9] Chitanana, L., and Govender, D. W. 2015. Bandwidth management in the era of bring your own device (BYOD). *The Electronic Journal of Information Systems in Developing Countries*, 68, 3, 1-14.
- [10] Chitanana, L., Makaza, D., and Madzima, K. 2008. The current state of e-learning at universities in Zimbabwe: Opportunities and challenges. *International Journal of Education and Development using ICT*, 4, 2. Available from: <http://ijedict.dec.uwi.edu/viewarticle.php?id=450>.
- [11] Rofiq, M., and Malang, K. A. 2013. Perancangan Manajemen Bandwidth Internet Menggunakan Metode Fuzzy Sugeno. *Jurnal Ilmiah Teknologi dan Informasi ASIA*, 7,1.
- [12] Amin, R. A. A., and Indrajit, R. E. (2016). Analysis of effectiveness of using simple queue with per connection queue (PCQ) in the bandwidth management (A case study at the Academy of Information Management and Computer Mataram (AMIKOM)). *Journal of Theoretical and Applied Information Technology*, 83,3, 319.
- [13] Gharakheili, H. H., Exton, L., and Sivaraman, V. (2016, January). Managing home routers from the cloud using Software Defined Networking. In *13th IEEE Annual Consumer Communications & Networking Conference (CCNC)*, 2016, 262-263. DOI: 10.1109/CCNC.2016.7444771