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AKSU-Netbands: An Adaptive Bandwidth Utilization and Monitoring System

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ABSTRACT

Traffic monitoring and analysis is needed to troubleshoot and resolve problems as they occur to prevent total collapse of a network. There exist numerous methods and tools to effectively monitor and analyze network traffic. The performance of a network can degrade drastically due to inefficient management of network traffic. In this paper, "AKSU-NETBANDS: An adaptive bandwidth utilization and monitoring system" is proposed to monitor network performance. The objectives of this work are to design a system that can monitor the activities of users, generate daily reports and also to design an adaptive roll-over mechanism based on bandwidth usage for each user category. The proposed system should have the ability to restrict video streaming and Windows updates as a means to effectively manage available bandwidth. The research methodology used in the design of the proposed system is a combination of interview, observation, review of state-of-the-art and the Agile software development life cycle. The results show that the proposed system has improved efficiency over the existing system by restricting Windows updates, online video streaming and has the ability to roll-over unused bandwidth allocated to each user of the system. The proposed system is implemented using Hypertext markup Language (HTML), JavaScript, Hypertext Preprocessor (PHP) and My Structure Query Language (MySQL) Database Management System.

Keywords: Bandwidth, Monitoring, HTML, PHP, MySQL, Adaptive, Administrator, Network, Packets, Utilization.

1. BACKGROUND TO THE STUDY

Network bandwidth usage monitoring is the most critical function for any network administrator. Network administrators are constantly striving to maintain smooth operation of their networks. Network outage even for a small period of time could cause the productivity within a company to decline. In the case of public service departments, the ability to provide essential services would be compromised. In order to be proactive rather than being reactive, administrators need to monitor

network performance in terms of latency, packet size, bandwidth usage and throughput to ensure that breaches do not occur within the network. The aim is to achieve different ways to effectively manage bandwidth to maintain peak network performance. Network monitoring helps administrators to understand the composition and complexity of the network they manage. It also gives the man insight into how individual elements within the network are performing at any given time. This is a key success factor in maintaining the performance and integrity of the network (Behr *et al.*, 2012).Monitoring and diagnostic capabilities are critical to today computer networks because their effectiveness determines the quality of the network service delivered.

The most important performance metrics that are monitored include connectivity, delay, packet loss rate, and available bandwidth (Ningning, 2006). Network saturation can lead to traffic congestion or packet loss that can have negative impacts on the users. Reliable bandwidth monitoring tools can assist by avoiding and dealing with these problems, and they can help to appropriately distribute bandwidth across the network (Spiceworks Inc., 2006-2016). Netmon is designed by (Rogozhkin, 2005), for performance monitoring of a packet data network, which measures network performance statistic using Simple Network Management Protocol (SNMP) information polled from backbone router. This approach does not provide information of host computer and network path. Hence, it is not suitable to be used as a network monitoring tool for the resource management middleware.

Bandwidth utilization is a means of allocating bandwidth capacity to critical applications on a network to meet organizational objectives. Without bandwidth utilization, an application or a user can take control of all available bandwidth. Knowledge of up-to-date bandwidth utilizations and path latencies is critical for numerous important network management tasks including resource management as well as providing and verifying Quality of Service (QoS). (Yuri *etal.,*2000).Priority policies allow network administrators to control congestion, provide users with limit on bandwidth usage and also account for service provider cost (Austin, Peter& Jacot, 2001). User involvement in allocating bandwidth is minimal since the bandwidth is sent according to the predefined priority policies by the network administrators. A network traffic monitor can also help administrators avoid excessive spending and incurring broadband overage fees (Spiceworks, 2016).

According to Bolliger (2004), a network-aware application has two basic aspects: it must have the ability to monitor or get information about the current status of the underlying network and to be able to adjust its behavior based on the collected information. With this approach it can enhance the reliability and quality of a network. Wucherl & Alex (2004) developed a network bandwidth utilization forecast model, which can support efficient network resource utilization, efficient scheduling, alternate path finding, and planning on network link/bandwidth. The univariate model is developed with Seasonal Decomposition of Time Series by Losses (STL) and Auto Regressive Integrated Moving Average (ARIMA) on Simple Network Management Protocol (SNMP) path utilization data. It is challenging to efficiently coordinate network resources on a shared network. In addition, sudden bandwidth utilization change makes forecast more challenging.

Yuri et al. (2000), addressed the problem of efficiently monitoring bandwidth utilization and path latencies in IP networks. Unlike earlier approaches, this measurement architecture assumes a single point-of-control in the network corresponding to the Network Operating Centre (NOC). This approach is also applicable to a distributed monitoring setting, where a number of NOCs/ "monitoring boxes" have been distributed over a large network area with each NOC responsible for monitoring a smaller region of the network.

The NOC is responsible for gathering bandwidth and latency information using widely-deployed management tools, like SNMP, RMON/NetFlow, and explicitly-routed IP probes. Using this model, a novel approximation algorithm for these optimization problems was used and also proved guaranteed upper bounds on their worst-case performance. Mohammad, Irda, Zaheera, & Syarulnaziah (2011), proposed a new service in Nagios which is capable of monitoring network bandwidth, sending alerts via email and generating graphs. These features were added to the existing system which has no such services. The bandwidth monitoring and notification system is configured to alert network administrators when the bandwidth usage of an organization's network hits a certain threshold setting with the help of the Nagios application.

Barry et al. (2005) developed a work which can fit into existing community networks and has been constructed to effectively manage and monitor bandwidth usage. The system integrates a number of Open Source Software (OSS) applications to provide monitoring and management of bandwidth usage within the community network. The system replaces the network routers throughout the community network with custom-developed routers which have added functionality. The additional functionality includes a caching proxy server to decrease Internet usage for frequently accessed websites, user and host-based internet usage quotas which can be employed to limit users' and hosts' Internet use to an acceptable level and monitoring critical servers or services within the network. This allows the system to pin-point any faults within the community network. A web-based front-end to the system was developed, which provides a single portal for administrators to manage their network .Niels et al. (2014), proposed a monitoring solution called OpenNet-Mon, written as a module for the OpenFlow. OpenNet-Mon continuously monitors all flows between predefined link-destination pairs on throughput, packet loss and delay.

1.1 Statement of Problem

The existing wireless network in Akwa Ibom State University is faced with the following problems with regards to bandwidth allocation and usage: unrestricted user permission to run Windows updates using Mikrotik and inability to adapt to user network activities for bandwidth roll-over. Based on the aforementioned problems there is need to develop an adaptive bandwidth utilization and monitoring system which will enhance the efficient use of bandwidth and network services for the institution as mentioned earlier.

3. Objective of the Study

The main objective of this study is to design a system that can monitor the activities of users and generate daily reports, to design an adaptive roll-over mechanism based on bandwidth usage for each user category using PHP, Batch script and MySQL Database Management System. The proposed system should have the ability to restrict video streaming and Windows updates as a means to effectively manage available bandwidth.

2. ANALYSIS OF THE EXISTING SYSTEM

The Akwa Ibom State University is a multi-campus university with two campuses. Internet is provisioned on the network through A Microwave Radio link, provided by Airtel Nigeria (Internet Service Provider) at the two campuses. It provides 20Mbps of bandwidth traffic to the Ikot Akpaden

campus and 8Mbps of bandwidth traffic to the Obio Akpa campus. For both campuses, the Internet bandwidth terminates into a Mikrotik Gateway Router. The Mikrotik Gateway Router has the following major security features: Firewall and Network Address Translation (NAT) routing, data rate management and point-to-point tunnelling protocols. The Mikrotik Gateway router supports Layer-2 connectivity such as wireless bridge, Integrated Services Digital Network (ISDN), Virtual LAN (VLAN) and Symmetric Digital Subscriber Line (SDSL). The network infrastructure is divided into Internet Service Provider (ISP) inbounds Internet packets and the university outbound Internet packets. The Mikrotik Gateway is designed to filter packets coming into the network and to utilize the given bandwidth effectively by creating firewall rules that helps shape the Internet traffic sent to users within the university network.

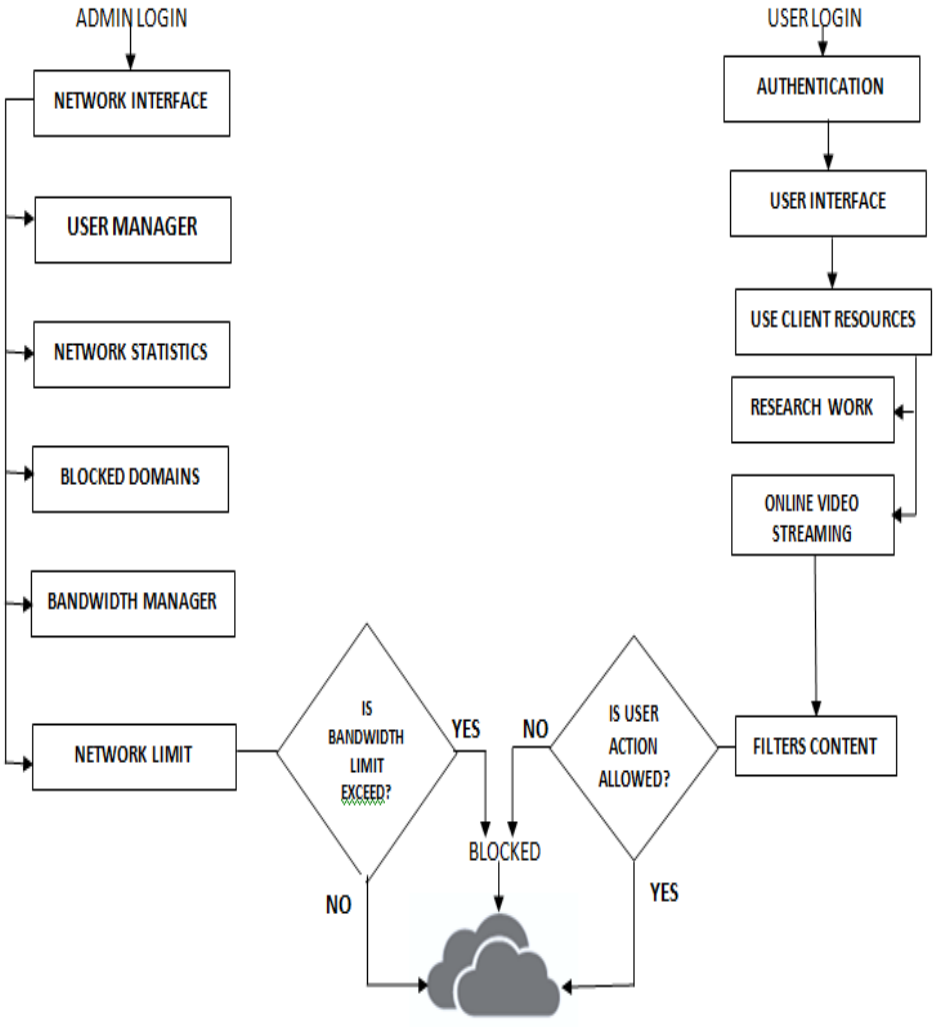

Fig. 1 Existing Architecture

The Mikrotik Gateway has a User Manager Interface for creating Internet Profiles for several categories of users such as students, teaching staff, non-teaching staff, Principal Officers of the university etc. Each profile type is configured with bandwidth speed limits, data usage limits, duration of use by each user and login authorization to the network. The network uses a Star topology where different buildings within the campuses are connected directly to the Mikrotik Authentication Gateway through a switch. This configuration allows packets from the Gateway to be transmitted directly to the various client points within the university.

3. METHODOLOGY

3.1 The Research Design

The research methodology used in this project is a combination of interview, observation, literature searches and review and agile software development model. The choice of the Agile model is based on the fact that it gives more emphasis to sustained and quick development of product features rather than spending more time during the initial project planning phase analysing the actual requirements. It is suitable for network monitoring because it is flexible and adaptable. The Agile model is the preferred model because it enables the analyst to break down the software development into smaller modules while integrating documentation and quality testing at every problem step. The system developed here is resilient to change resulting in a higher level of confidence in the correctness of the software which helps to reduce the risks in developing complex systems.

3.2 Proposed System

The proposed system architecture shown below in Fig. 2 seeks to reduce the high rate of bandwidth consumption as a measure towards effectively managing and utilizing available bandwidth in the existing system.

The network administrator logs into the network through the Network Interface and can monitor the activities of users and generate report based on user activity that enable the administrator block user domain. The bandwidth manager shows the total amount of bandwidth used. Network limit places daily cap for each category of user on the network and this system also rolls over 15 percent of bandwidth for any category of user that has not used the allocated data for five working days. The User Manager adds a user and controls the activity of all active users. This system permits a user to login using a Unique Identification number (UID) to access resources. The proposed system filters packets by creating firewall rules that limits users from updating windows or streaming videos online as a way of utilizing and effectively managing available bandwidth. Every user activity is saved in a database for subsequent retrieval. This provides valuable audit trail for network administrators to use in analysing user network use pattern.

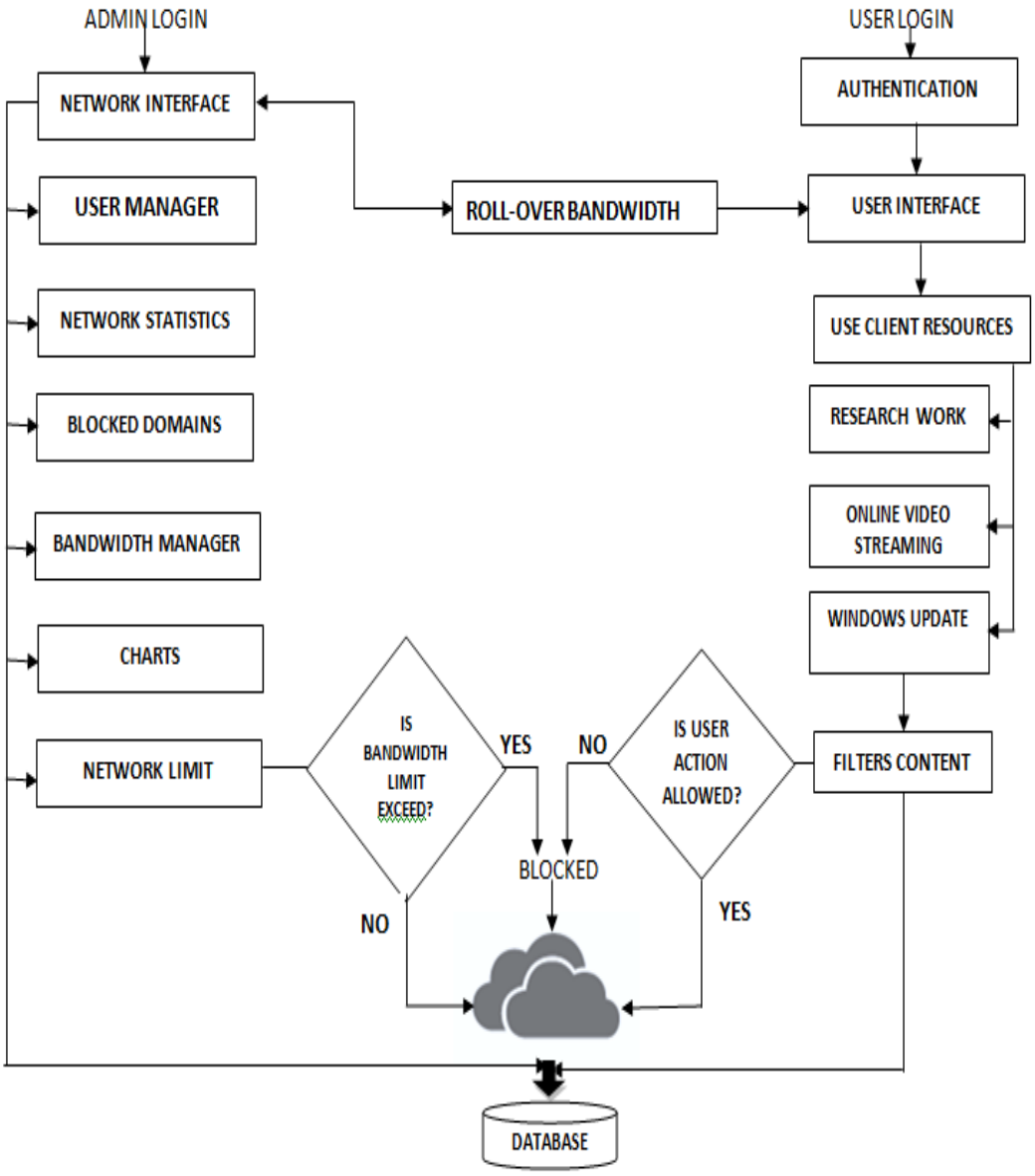

Fig. 2 Proposed System Architecture

4. DATA REPRESENTATION

The main performance metric used in this work is bandwidth. Users need to register on the platform using the provided secured login interface, and are allocated bandwidth based on user categories. The category is determined based on designation, for example, student, academic staff, administrative staff, etc., and auto-set at registration based on user credentials. Fig. 3 below illustrates some registered users' profiles and bandwidth allocated by admin.

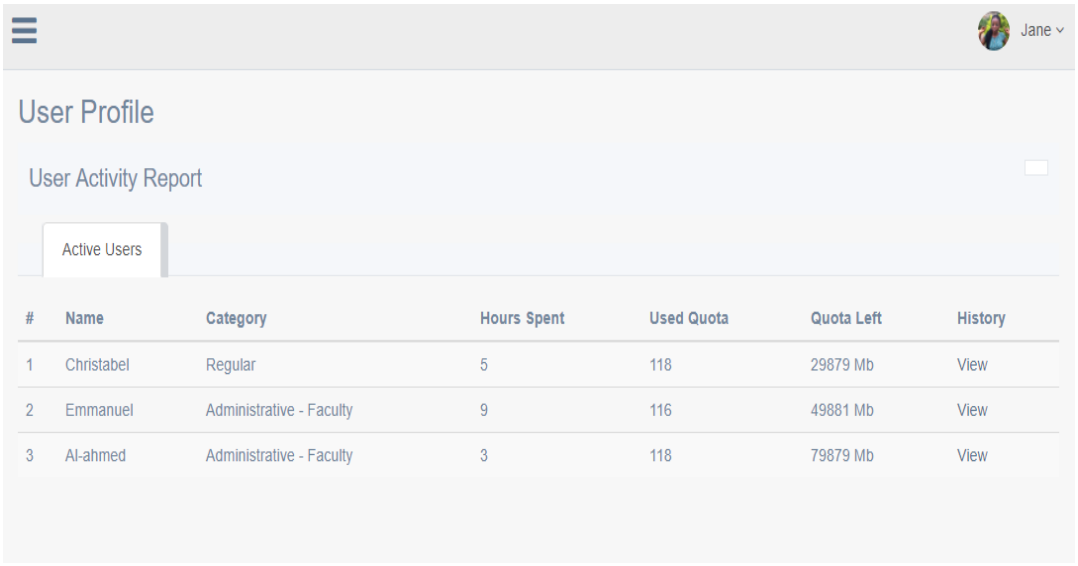

Fig. 3: Active Users and allocated bandwidths

The bandwidth usage is monitored on a weekly basis and a certain percentage of any unused quota is rolled over to them for the subsequent week. In this work 15 percent was rolled over back to users, however, this is flexible and may be adjusted as need arises by network admin. Fig. 4 below is a chart showing allocated bandwidth and actual bandwidth used for 12 users monitored over a week. From the chart we see that only two users exceeded their allocated bandwidth, while the remaining 10 users consumed minimal bandwidth. If monitored over long periods of time, User patterns can be established and used to efficiently manage bandwidth allocation to registered users, ultimately saving costs for management. This could be achieved by reassigning a portion of bandwidth allocated to light users to heavy users.

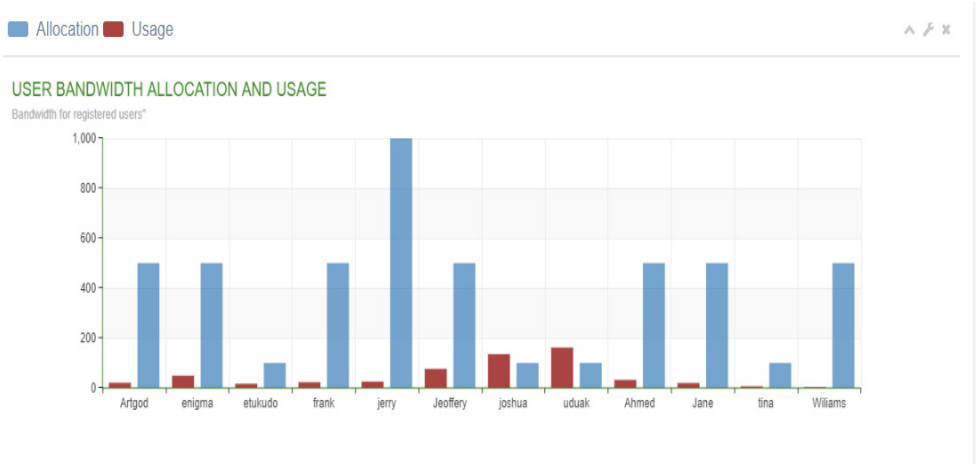

Fig. 4: Bandwidth allocation and usage for various users

Another major contribution of our work is bandwidth usage maximization. Windows update is known to consume reasonable amounts of bandwidth, and there is no guarantee that all users on a network will turn off the updates. With NETBANDS, the network administrator can automatically disable all windows updates across the network. Fig. 5 (a and b) display pie charts of data usage by various applications over the network. In (a), disabling Windows updates frees up more bandwidth for Web applications compared to (b) with Windows updates enabled. Since most of the end devices in a typical university network are personal devices of students and academic/administrative staff, they may as well update them using their private networks.

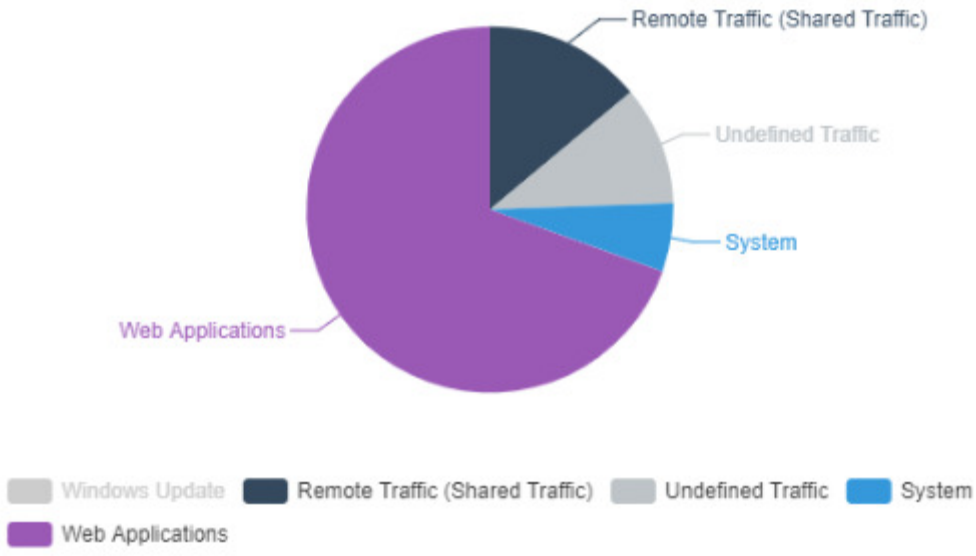

Fig. 5(a): Bandwidth consumption by applications with Windows Update disabled

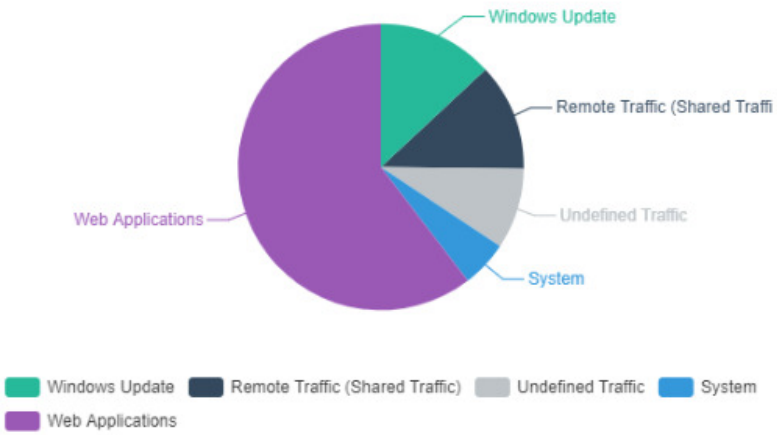

Fig. 5(b): Bandwidth consumption by applications with Windows Update enabled

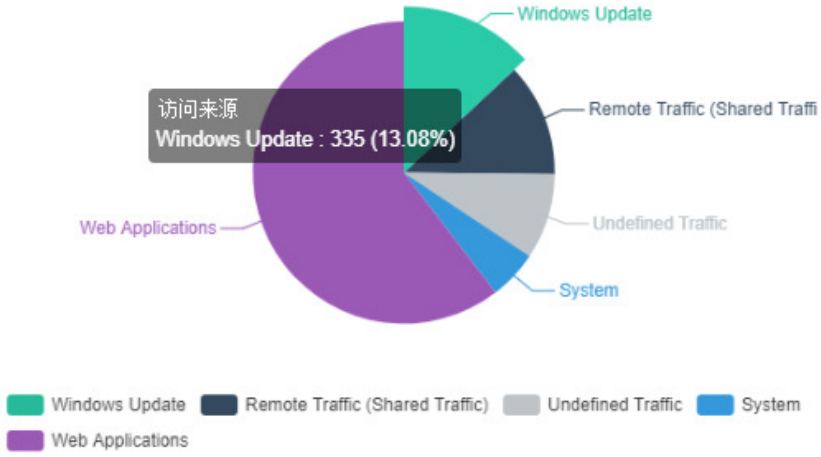

Fig. 11 Percentage of Bandwidth used by Windows Update

5. DISCUSSION OF FINDINGS

Evaluation is important to assess the worth or merit of a project and to identify areas for improvement. The evaluation approach, design and methodologies should match the specific project. To effectively monitor, manage and utilize available bandwidth, the proposed system ensures that a user is blocked from accessing video streaming sites or initiating Windows updates by introducing web content filtering mechanism. With these measures in place, the application is able to control bandwidth wastage which reduces cost. The proposed system allows the network administrator to track the amount of bandwidth used across the network and what is available to avoid incurring charges for unused data. This eliminates process of windows update consuming bandwidth allocated by the administrator without being adequately used by the user. This proposed system is adaptive because it has a mechanism to roll-over 15 percent of unused allocated bandwidth to a user if he/she has not used t used his/her allocated bandwidth for five working days. Based on the choice of programming language used, the proposed system provides users with fast access to network resources.

6. CONCLUDING REMARKS

With the growing need for network, nearly every organization require network to access resources. There is therefore need for solutions that can provide efficient and secure means of network access and monitoring for effective bandwidth utilization. NETBANDS could help organizations achieve this as can be deployed securely to increase user productivity while saving costs on data significantly. It rolls-over 15% of the bandwidth size of a user that has not used the allocated data for five working days. Over time, users' bandwidth usage patterns could also be established for effective user bandwidth allocation based on established pattern. This can lead to reduced data purchase costs as well.

7. CONTRIBUTIONS TO KNOWLEDGE

Other than contributing to knowledge this work presents relevant contributions to firms, especially educational institutions, through partitioned network and controlled data usage. Reserved bandwidth can be deployed for research and registration for students. User activities can be tracked as well as comprehensive reports generated.

8. FUTURE WORK

This work could further be extended in the area of data analytics, monitoring of users' network usage patterns over time and used in important decision making by management. Such decisions could include amount of bandwidth purchased and allocated to registered users. The unused bandwidth could then be channelled or reserved for scientific applications.

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