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QoS ENHANCEMENT OF WIRELESS CAMPUS NETWORK USING THROUGHPUT PARAMETER

Ibrahim, A. L.[1] and Abubakar, A. M.[2]

1. Department of Information Technology Bayero University Kano Nigeria, ialawan.it@buk.edu.ng.
2. Department of Computer Science Ummaru Musa 'Yaraduwa Univrsity Katsina Nigeria, abubakar.muazu@umyu.edu.ng

ABSTRACT

In recent years, broadband wireless systems developed themselves as one of the fastest growing and emerging sector in the field of telecommunications. It is a network of multiple interconnected local area networks in a limited geographical area. Quality of Service (QoS) is considered as one of the key issue in Wireless Campus Network due to the bottleneck and the competition among different kinds of traffic flow on the network. In this paper a Short-Term and Long-Term models are developed to enhancements QoS performance for Wireless Campus Network using throughput parameter. The models were designed and simulated using Optimized Network Engineering Tool, OPNET IT GURU Academic Edition with linkages between wireless workstations suitable for implementation to determine the performance of the network throughput. The two versions contain the same number of wireless workstations, but with some additional access points and multiple processors in the long-term model, a point-to - point protocol (PPP) was used to link the access points to the routers and the cloud while using 100BaseT cable to connect. In each case, the wireless network throughput was obtained. The findings obtained from these models showed that, relative to the short-term model, the Long-Term model achieves higher wireless network performance. That may be due to the fact that while in both models the total number of wireless workstations is the same, the long-term model topology includes additional access points and double processors resulting in the observed minimum throughput.
Keywords- WLAN, QoS, Throughput, Wireless Workstations and OPNET IT GURU

INTRODUCTION

Junaid and Joel (2014) examined the consequences of deploying a new centralized course repository in the campus network of SUNY Fredonia and implemented mobile web clients using OPNET. They simulated web clients accessing the server which resides in the central network facilities on a Gigabit link. They also simulated and analysed the success of mobile Web clients in classrooms. Initial findings suggested marginal packet loss and irritating additional throughput but with server directly connected to the central switch, there was no significant improvement in the throughput. They also conducted another study related to Basic Service Set (BSS) wireless network infrastructure by varying the buffer size of the client and by tracking throughputs and errors. The results showed a decrease in low speed Wireless LAN (WLAN) errors and a rise in 11Mbps WLAN throughputs if the buffer size is increased. OPNET will then usefully and quantifiably investigate and assess the results of different modifications and complex configurations. IT Guru enables one to study and gather useful statistics about building a virtual network from it.

Coats et al. (2005) performed comprehensive research on Wireless LAN networks that studied users' behavioural trends in the network. The users' traffic and activities are investigated at regular, daily, and even weekly bases. For the weekly and daily trends the findings of this study were correctly apparent. They also found out that many wireless cards are being hostile by cooperating with the access points, leading to a large number of sessions becoming confused. In this research, it is suggested that the network designers find substantial incompatibilities about time and space for operations in the houses, access points, and cards.

Studies by Wang, et al. 2011) was conducted on the effects of separating space between the Aps on the device efficiency of a WLAN in Results showed that the greater the gap between the APs, the lower the output rate was.

In Protocol 802.11b the distance of 3 m is used between the APs, while for Protocols 802.11 g and 802.11n the distance of 4 m is considered. Local Wireless Area Networks (WLANs) are rapidly being used in households, businesses, public buildings and university campuses. Recently, the emphasis has been on creating Wi-Fi hotspots in conference centres, airports, shopping malls, hotels, public libraries, and cafes where people can access email, download files, search websites, or set up VPN connections to corporate networks while on the move. WLANs can be implemented inside a building or campus asan extension or as an alternative to a wired LAN. While the number of hotspot locations is growing, academic and industrial research have begun to think of applications that can use the network efficiently, which in return will meet the demands of their users for secure wireless Internet or web access. This trend has introduced network-aware applications that can dynamically adjust the demands of the users to suit the varying supply of network resources as defined in Figure 1.

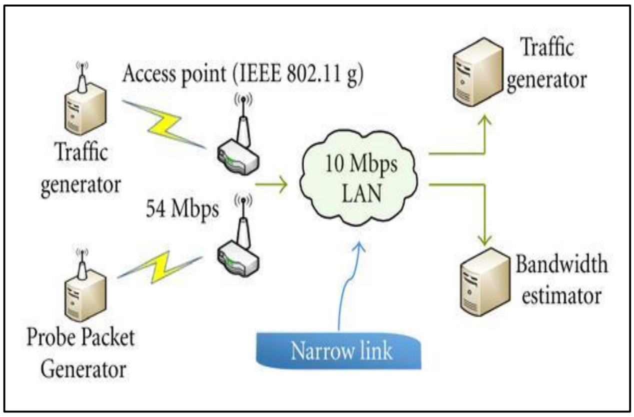

Figure 1. Wireless Campus e-Learning System

Currently WLAN demonstrates all IEEE 802.11 family protocols and standards. Motorola launched the first local, commercial wireless. It imposed, as an example of these networks, a high cost and low bandwidth that was in no way cost-effective. The IEEE 802.11 standard project began from that time on; i.e. in the early 1990's. After nearly 9 years of development, the IEEE adopted 802.11a and 802.11b standards in 1999, and several devices were released based on those standards.802.11a has a bandwidth of up to 54 Mbps using 5 GHz carrier frequency, while 802.11b allows up to 11 Mbps bandwidth using 2.4 GHz carrier frequency. However, in 802.11b, the number of usable channels is larger than that of 802.11a such networks differ in number depending on the countries listed (Chen et al., 2015).

The standard WLAN usually indicates 802.11b. IEEE, defined as 802.11 g, has recently launched yet another standard. This norm works on the basis of 2.4GHz carrier frequency but it can boost the available bandwidth by up to 54Mbps using modern methods. Based on this standard, which was not long developed and adopted, the manufacture of the necessary products started over a year and its compatibility with the 802.11b standard means that its use in wireless networks is slowly expanding.

It is important to note that today's standard-based wireless LANs run at high speeds – the same rates for wired networks that were considered state-of-the-art only a few years ago. The user's connectivity is usually more than 11 megabits per second (Mbps) or 30 to 100 times faster than the normal dial-up or Wireless WAN technologies. This bandwidth is definitely sufficient to provide a great user experience through the Desktop or mobile device for a variety of applications or services. Furthermore, continued development with these wireless standards continues to increase bandwidth at speeds of 22 Mbps. Many suppliers of broadband cable public areas around the world. Most airports, meeting canters, and several hotels can provide their guests with 802.11b connectivity over the next 12 months (Hussein et al. 2013).

Wireless local area networks provide important advantages in many areas. Firstly, local area wireless networks are more versatile and mobile than wired networks and will not be cable-limited. Users can connect or receive information in real-time at any network coverage. Second, there is good scalability to WLANs. Users may add more APs to efficiently extend the network so as to satisfy the needs of different applications and installations. Third, WLANs no longer need a lot of wires and cables, thereby reducing network cabling workloads. Finally, setting up a WLAN is simpler than a wired one, and cannot easily be influenced by the natural environment or disasters.

Czhusbaick (2015) stated that, using radio frequency as the transmission medium, a Wireless LAN allows workstations to communicate and access the network. The wireless LAN can be linked as an extension to an existing wired LAN, or it can form the basis of a new network. Wireless LANs are adaptable to both indoor and outdoor settings, but are especially ideal for indoor locations such as office buildings, floor manufacturing, hospitals, and universities. The Cell is the basic building block of the wireless LAN. It is the region where the wireless contact happens. A cell's coverage area depends on the intensity of the propagated radio signal and the form and structure of the indoor environment's walls, partitions and other physical features. Workstations, notebooks and pen-based computers based on a Desktop will travel freely inside the cell (Kotz and Essien, 2012).

Broadband wireless networks have developed themselves as one of the fastest growing and emerging fields of the telecommunications sector in recent years. Multimedia technologies such as audio, video, high definition TV (HDTV) or immersive games with guaranteed quality of service (QoS) are the latest trends and demands. In this paper a wireless Campus Network design will be develop to compare the QoS performance improvement of Wireless Campus Network using throughput parameter. Two models (Short-Term and Long-Term) will be design and simulate using Optimized Network Engineering Tool, OPNET, IT GURU Academic Edition that will link between two hundred and fifty, three hundred and fifty, five hundred and fifty and seven hundred wireless workstations, suitable for implementation. Simulate the designed network and to determine network throughput performance. The models will contain the same number of wireless workstations but with some additional access points in the long-term model. For both models, a point-to-point protocol (PPP) will be employed to connect the access points with the routers and the cloud while 100BaseT cable will be use to connect the servers and the firewalls.

MATERIALS AND METHODS

The approach is based on the software point of view that improve base on the design and implementation. The model will maintain the same physical infrastructure; hence no extra cost will be required for installing new hardware and equipment over the existing infrastructure. To achieve the above objectives, the Optimized Network Engineering Tool, OPNET, IT GURU Academic Edition will be use and also Access points, Router, Wireless workstations will be use. Finally, point-to-point protocol (ppp) will be use to connected the Access points, Router, Wireless workstations and the cloud and 100BaseT will be use to connected the servers with firewall to obtain the best connection that will satisfy objective of the research.

OPNET

Optimize the Network Engineering Method, OPNET; consists of modules each dealing with various aspects of network design. A modular module is used particularly for the design and simulation of networks. This helps the user to do the shooting of network power program, network setup and operation and network problems. The user will shape a whole network's behaviours. OPNET IT Guru Academic Version will serve as a simulator in this design. It is exceptional in that it is capable of modeling the entire network (Mittal, 2012).

IT Guru helps one to build a virtual network consisting of appropriate hardware, protocols and software applications (OPNET Corporation, slide 2 of "IT Guru Fast Start," presentation of the power point, 2004). Computer networking can be duplicated in a virtual IT Guru network. It can be scaled from just a two-station network to one containing tens of thousands running in a WAN.

Wireless Network Components

Client computers, access point, wireless network adapters, wireless routers, wireless controllers and wireless antennas are the key components of WLANs. Stations are also known as client computers. All end users with wireless capabilities, for example cell phones and laptops, can serve as client devices. The network interface cards, also known as wireless adapters, serve as WLAN interfaces and are essential for the devices when they want to access WLANs. There are three different types of network interface chips, PCMCIA, PCI, and USB included. The PCMCIA cards are designed for the laptops and allow hot swapping, which means users can remove or attach cards to the network interface without shutting down machines. The PCI cards are appropriate for desktop computers while the USB sticks are appropriate for both desktop and laptop computers (Rahul et al., 2011).

The point of entry acts as a link between wireless devices and wired networks. For large buildings, APs are widely used to establish a wireless local area network extending to a wide variety of locations. Home users can add an AP but not a router if they want to extend their network, and office users can connect more than one APs to the whole building to broaden the network. Wireless controllers include load balancing, including complete identification, and identification of correction and disturbance (Zhang and Yu, 2013).

The Wireless controllers used to handle and configure a collection of APs automatically. The Wireless Evasion apps (Leith et al., 2020). According to Wang et al. (2011) WLANs also contain antennas. Antennas have the purpose of transmitting and receiving electromagnetic waves, so users can extend wireless LAN coverage by using antennas. When wireless devices are far from the AP or other devices, the transmitting rate is greatly reduced and antennas can come in handy to improve the signal and also speed up the transmit rate.

Throughput Model

The mathematical model for Quality of Service parameters is discussed in this section with respect to the throughput. The average data rate of effective message transmission over a contact channel is the throughput (Yasukawa et al., 2019). The equation below can be used to model the throughput to the aggregate throughput:

$$Throughput = \sum_{i=1}^{n} PacketSize_i \qquad (2.1)$$

But to find the instantaneous throughput per unit time, it will be divided by t.

$$Throughput_{SS} = \frac{\sum_{i=1}^{m} PacketSize_i}{t} \qquad (2.2)$$

where:

t is the unit of time to calculate the throughput

PacketSizei is the size of ith packet received in bytes

n is the total number of packets received at the destination

m is the total number of packets received at the destination in time t

$m \leq n$

Throughput Model for TCP

Throughput for Transmission Control Protocol (TCP) packet sessions can be calculated for scenarios of packet loss and no packet loss, separately.

If no packet loss:

The throughput at the destination (data received) will be:

$$Data\,\mathrm{Re}cieved_{Destination} = \sum_{i=1}^{n} packetSize_i \times \left(\frac{T}{RTT}\right) \qquad (2.3)$$

where:

Round Trip response Time (RTT) is the propagation time for data between client and server

Therefore the throughput at the Subscriber Station is:

$$Throughput_{SS} = \frac{Data\,\mathrm{Re}cieved_{Source}}{t} \qquad (2.4)$$

If there is packet loss:

The throughput at the destination (SS) can be calculated when there is packet loss as:

For a successfully delivered packet,

$$Throughput_{SS} = \frac{\sum_{j=1}^{m}\left(w_1 + \sum_{i=2}^{n}(w_{i-1} + \beta)\right)}{t} \qquad (2.5)$$

And for a lost packet,

$$Throughput_{SS} = \frac{\sum_{j=1}^{m}\left(w_1 + \sum_{i=2}^{n}\frac{w_{i-1}}{2}\right)}{t} \qquad (2.6)$$

where:

wi is the congestion window at initial interval *i*

w_1 is the congestion window

t is the unit of time in seconds

β is the increase in the congestion window
m is the number of packets sent at source
$n = m-1$

The proposed Long-Term model should have high throughput as it decreased the control traffic using the Short-Term model. Hence, there should be less packet loss in the network, and maximum packets will be received by the SSs. This will increase the throughput

Analytical Results

In this section, the analytical throughput model for the Short-Term and Long-Term models.in the Wireless Campus Network models result is plotted using the following assumed parameter values as shows in Table 1.

Table 1 Throughput parameter's value for proposed Short-Term and the Long-Term Models

PARAMETRES	NOTATIONS	VALUES
The data received in kilobytes	*Data received in kb*	950 kb/s
Time to process the data in seconds	*Time in sec*	*10 s*

Using these parameters the throughput graph for the proposed Short-Term and the Long-Term Models can be illustrated as in Figure 2.

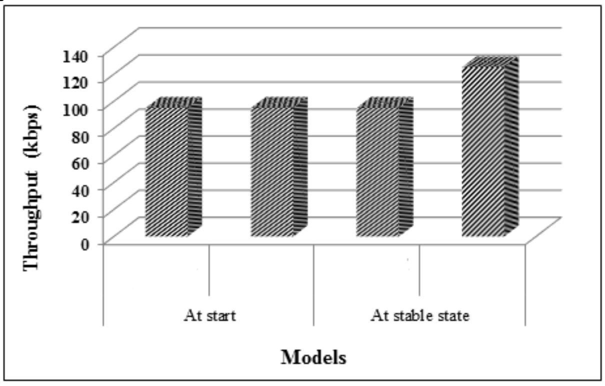

Figure 2. Analytical Results for Short-Term and the Long-Term Throughput Models

The analytical result in Figure 2 shows that the throughput of the proposed Short-Term and the Long-Term Models has the same value at the start as all the Base Stations of the two models will receive data from the central server.

Simulation Process Overview

The workflow scheme of OPNET is split into four steps: building new network models; selecting individual statistics; running simulations; and viewing / analysing tests. The network models were developed for both the proposed Short-Term model and the Long-Term model. All required components of the network were selected from the object palette and generated within the workspace. Parameters for the network components and device settings were then selected to include host IP addresses, packet and buffer sizes, etc. The network was subsequently developed and prepared for the statistics needed for performance evaluation for the different applications needed.

Next, Wireless Campus network custom applications were chosen and set from global statistic pools, including simulation duration and values per metric. In this paper, the throughput parameters is set to run for 8 Hours for both models. All the simulation errors encountered during simulation were displayed in the simulator windows. If there are simulation errors, then the simulation process is repeated from Step 2 of the simulation process in Figure 2 (set the parameters for the network component and choose the application). The absence of errors takes us to the next step in the simulation process. The results collected were analyzed with the goal of evaluating results and recognizing performance and any network issues. When the desired results are obtained, the simulation process is complete; otherwise the entire procedure (from step 2) is repeated as shown in Figure 3.

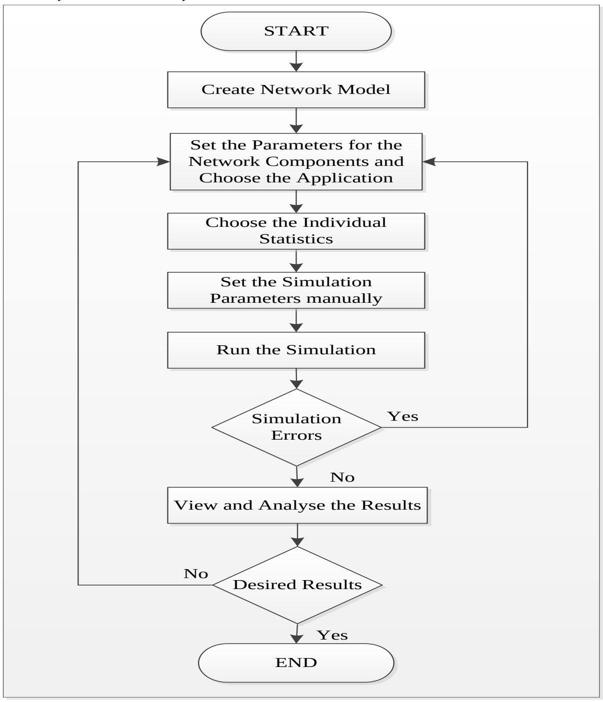

Figure 3. Simulation Process Overview

Quality of Service Parameters

Quality of Service (QoS) provisioning encompasses providing the end user the best service in terms of several generic parameters that can be quantitatively measured by several parameters. For this research Throughput was considered.

Throughput is a measure of the rate of data produced by the application (bits per second). From the packet ID trace file, each data packet keeps track of the packet from the moment a packet is sent to the time the packet is received, and its packet size is stored with all packets reaching the same destination (Yasukawa et al., 2019). In order to measure the throughput, the size of each packet has been applied to give a total for all transferred data. The overall time, however, was measured as the difference between the time the first packet began and the time the final packet reached its destination. Thus, throughput equals total transferred data divided by the total transfer time taken.

Simulation Setup and Configurations

The first part of this section presents the Integrated Network Engineering Method, OPNET IT GURU Academic Edition, which links up suitable wireless workstations. An overview of the simulation process and the QoS parameters used to simulate and evaluate network performance. This is accompanied by explanations and a comparison of QoS results between the Short-Term and Long-Term Models proposed. Finally, the section outlined the specifics of the simulation parameters and the scenarios planned for both the proposed short-term and long-term models.

Scenarios for Short-Term Model

In scenario 1 of the short-term Model, the campus was divided into two (2) separate sites (old site and new site) with two hundred and fifty wireless workstations each network having its own access point single processor. The two access points are connected together using a point-to-point protocol (PPP) employed to connect the access points with the routers and the cloud while 100BaseT cable was used to connect the servers and the firewalls. In scenario2, scenario3 and scenario 4 of the short-term Model the wireless works were increased to three hundred and fifty, five hundred and fifty and seven hundred respectably. All other parameters configuration remained as configured in scenario1 as describe in figure 4.

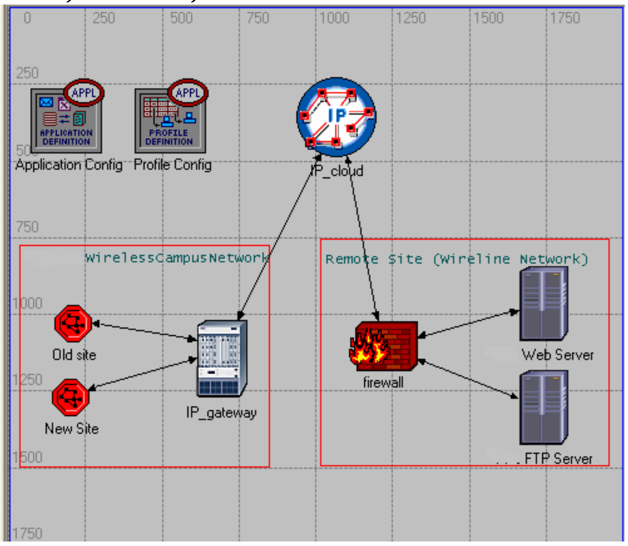

Figure 4. Wireless Campus Network Design for Short-Term Model

Scenarios for Long-Term Model

In this scenario for Long-Term Model, the campus was also divided into two (2) separate sites (old site and new site) with additional subnet to each site, each network having one access point with double processor. The four access points are connected together using a point-to-point protocol (PPP) employed to connect the access points with the routers and the cloud while 100BaseT cable. In scenario2, scenario3 and scenario 4 of the short- term Model the wireless works were increased to three hundred and fifty, five hundred and fifty and seven hundred respectably. All other parameters configuration remained as configured in scenario1 as illustrates in figure 5.

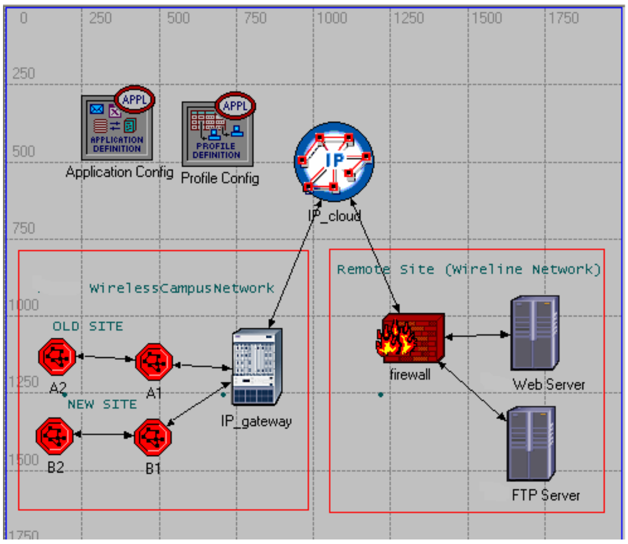

Figure 5. Wireless Campus Network Design for Long-Term Model

RESULTS AND DISCUSSION

This section discussed the analysis of the results obtained as a result of the simulation of the different network designs for the Short- Term and Long-Term Model. All the statistical graphs obtained as a result of the simulation are displayed. Discussion of the outcome of the results in relation to each other was carried out. Attention was given to significant findings.

Observed Wireless Campus Network Throughput

The results of the global statistics known as Wireless Campus Network Throughput for all the scenarios of the two models were summarized in the table below:

Table 2. Wireless Campus Network Throughput.

S/N	SCENARIO	SHORT-TERM MODEL (bits/sec)	LONG-TERM MODEL (bits/sec)
1.	Scenario_1	1420.53	1585.34
2.	Scenario_2	2066.23	2298.76
3.	Scenario_3	3158.28	3367.77
4.	Scenario_4	4105.98	4355.23

Scenarios Simulation Results for Throughput Comparison

It can be observed from Figure 5 that the Long-Term Model experiences much lower wireless network throughput compared to the short-Term Model. This could be attributed to the fact that even though the total number of wireless workstations are the same in both model for scenario_1, scenario_2 scenario_3 and scenario_4, but the topology of the long-term model contains additional Access Points and double processors which resulted to the observed minimum throughput as indicated in Figure 6 below.

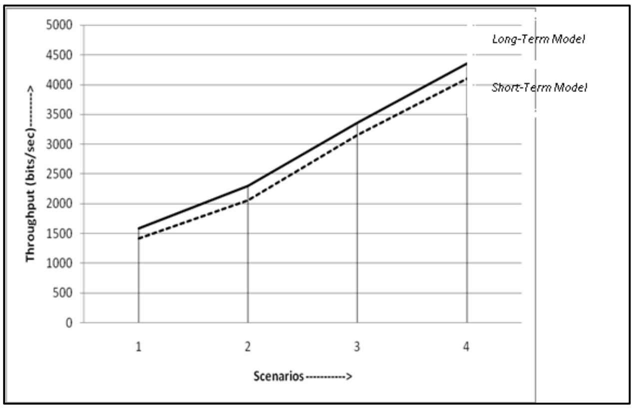

Figure 6. Wireless Campus Network Throughput for Short-term and Long-term Models

CONCLUSION

One of the major problems in Wireless Campus networks is the perceived quality of service (QoS) by the users. There are various levels of QoS being offered to the users either based implicitly on application specifications or directly on defined Service Level Agreements (SLA) between the users and the network service providers. Perceived QoS can be measured using a few key metrics such as packet loss, throughput, delay and jitter. In this research a wireless Campus Network architecture was proposed based on two models (Short-Term and Long-Term models). The two models have the same number of wireless workstations but the long-term model contains several additional access points and multiple processor. Two access points and a single processor were used in the short-term model, while four access points and multiple processors were used in the long-term model. A point-to - point protocol (PPP) was used for both models to link the access points to the routers and the cloud while 100BaseT cable was used to link the servers and the firewalls. The simulation of the two models was performed using OPNET IT Guru Academic Edition. The long-term model was found to have highest networking throughputs.

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