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Performance evaluation of campus network involving VLAN and broadband multimedia wireless networks using OPNET modeler

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ABSTRACT

Modern technology is essential for all healthy, economic, and educational sectors. Using modern technology involves high-performance networks in terms of quality of service (QoS) parameters such as delay, throughput, bandwidth, and security. A campus network involves wire and the wireless environment with and without virtual local area network (VLAN) technology has been simulated using optimized network engineering tools (OPNET). The simulation model includes four scenarios that involve heavy-loaded File transfer protocol (FTP) and web browsing applications with two logical groups of users. The simulation results show that the VLAN overcome LAN networks in terms of bandwidth and security. This has been done by reducing the throughput in both sending and receiving levels to the confidential servers. The VLAN has also reduced the broadcast domain which results in a high-power efficiency. Moreover, the VLAN network technology has been proved to have lower values of delay in transferring files and packets than LAN network technology. In addition, VLAN technology generally has been decreased values of throughput regardless of the way of connection between servers and workstations. This, in turn, allows taking advantage of wireless connection features in terms of flexibility of installation and speed of configuration.

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1. INTRODUCTION

The increased demand for data transfer opened the way for the integration between technologies of computer networks such as local area network (LAN), virtual local area network (VLAN), and wireless local area networks (WLAN) to provide customers with useful applications [1], [2]. LAN is typically characterized as a broadcast domain, implying that all associated devices are located in the same LAN physically [3]. However, VLAN can be described as a set of devices that are located in various LAN segments which can connect like those devices that are located in the same physical LAN [4]. In other words, VLAN provides the engineers of networks with the ability to design logical networks instead of physical networks [5]. VLAN can be utilized to isolate the network into several broadcast domains with no latency issues [6]. VLAN trunk is

utilized to connect switches that help several VLAN crossing similar ethernet cables. Each frame conveyed between switches is labeled by the switches to determine the destination VLAN. VLAN depends on the IEEE 802.1Q standard that determines the labeling frame design [7].

In previous research, VLAN was used with hot standby router protocol (HSRP) to efficiently and stable usage of campus network resources based on dual-core architecture [8]. Another research suggested using VLAN with several applications between two campuses far from each other in order to take advantage of the features of VLAN in terms of reducing installation costs, facilitating network management and maintenance, increasing network security and protection while improving data transmission efficiency [9]. Other research suggested using VLAN and inter-VLAN to design the university network and provide the flexibility to connect users' devices to all networks within one group with the same internet protocol (IP) address, which leads to reducing cost and complexity [10]. Another research presented a modern design based on VLAN technology by dividing the main network into subnets. Three types of VLANs have been proposed which are default, management, and native using packet tracer. The results showed the ability of the VLAN to isolate traffic, regardless of the geographical location of the connected device or the type of network [11].

VLAN gives various advantages, including simplicity of the monitoring and controlling, reduced traffic resulted from high broadcasting, and execution of security approaches [12]-[14]. VLAN technology has also many benefits that are showed below:

- Performance: VLAN divides high broadcast traffic into several domains of the little broadcast which decreases the unimportant traffic in the network by sending traffic just between devices that are joined to a similar VLAN. This method decreases traffic which reflects positively on the delay and the bandwidth.
- Organization: VLAN can combine between hosts that have the same job characteristics which consider an easy way to be applied if it's compared to a huge broadcast domain.
- Security: important information can be gotten to by other users on a similar network, however by using VLAN, the security of the network can be significantly improved by making hosts receiving important information on private VLAN and so decreasing hosts obtaining the broadcasting frames.
- Power efficiency: a high-power efficiency can be accomplished by decreasing the broadcast domain [15], [16].
- Cost-effective: It is useful to utilize VLAN to make domains of the broadcast that are considered cheaper than the expensive routers.

VLAN can be used to reduce the collision in the traffic of a huge network. As mentioned, the VLAN divides the LAN network into various domains of broadcast for various packets which results in decreasing the intricacy of the network design. Also, VLAN has been involved to achieve routing traffic instead of the actual router. This strategy decreases the opportunity of a collision happening and enhances the performance of the overall network in terms of quality of services (QoS) parameters which include delay, utilization of bandwidth, data rates, and security [17]. Despite the fact that enthusiasm of end-client for VLAN using still in the beginning, many network companies have started to search for vendors who have a very developed VLAN system. Network devices just help to apportion on a port level, so VLAN can be shared across devices by utilizing devoted cabling between VLAN [18].

VLAN technology presents good solutions that can fix the LAN issues. VLAN approach has been implied in solutions of switched LAN by LAN hardware vendor. VLAN technology provides virtual separated LAN from other LAN segments. The researchers use this technology to protect the network from unauthorized access. VLAN can't be utilized for increasing network data rates; however, it is used for dividing clients into several segments [19]. On the other hand, VLAN can additionally provide various channels between clients to raise data rates. All clients are joined in VLAN segments that are connected by various links. Each pair of clients can utilize various links to transfer throughput. Furthermore, layer 2 provides more security than a higher layer for applications that are more affected by delays, like online games and video conferencing [20].

The wireless communication systems inside a small area, for example, an office building, university's campus, or house are called WLAN [21]-[24]. The speed of transferred data in WLANs is less than that speed using wires, but WLAN has some advantages over wires [25], [26]. WLAN permits portable devices such as cellphones and laptops to move through a building and communicate with other devices in the LAN through a wireless network to transfer data, without the need for wires [27]. Nodes can be changes randomly in wireless networks which provide the networks with the needed flexibility to meet the requirements of hosts and clients in terms of installations and configurations [28]. Wireless fidelity (Wi-Fi) includes many standards for WLAN networks depending on throughput and frequency. For example, IEEE 802.11 protocol is one of the most common wireless standards that are utilized to secure WLAN communication and to share network resources [29]-[31].

From above, it has been noticed that the campus network using VLAN with broadband multimedia wireless networks involving heavy-loaded file transfer protocol (FTP) and web browsing applications has not

been applied in previous research. So, in this paper, the performance of campus network has been evaluated using VLAN with broadband multimedia wireless networks involving applications that are heavy-loaded FTP and web browsing. The matrices, which have been measured for performance evaluation of the campus network in this search, include delay and throughput. Delay in any network is defined as the time needed for delivering data from the transmitter to the receiver. Whereas throughput represents the data rates that are transmitted and received successfully and it is measured in bits per second. The simulation has been achieved by using the optimized network engineering tools (OPNET) modeler. This article is organized as follows: in section 2, the system model has been presented. Then, the simulation results have been displayed in section 3. The conclusion has been shown in section 4.

2. THE SYSTEM MODEL

The campus network has been supposed with four buildings that serve 40 users in both wired and wireless techniques. The network has two servers to support file transfer and web applications for heavily loaded networks. Web applications sometimes denote hypertext transfer protocol (HTTP) applications. This system model has been examined with VLAN and LAN (No-VLAN) technologies. The performance is tested with wire and wireless servers in each technology. Therefore, four scenarios have been built which are wire servers with No-VLAN, wire servers with VLAN, wireless servers with No-VLAN, and finally wireless servers with VLAN. The users are divided into two logical groups which are staff and students. Figure 1 shows the visualize of the system model with baseline servers. Then, Figure 2 depicts the VLAN technology with wireless servers.

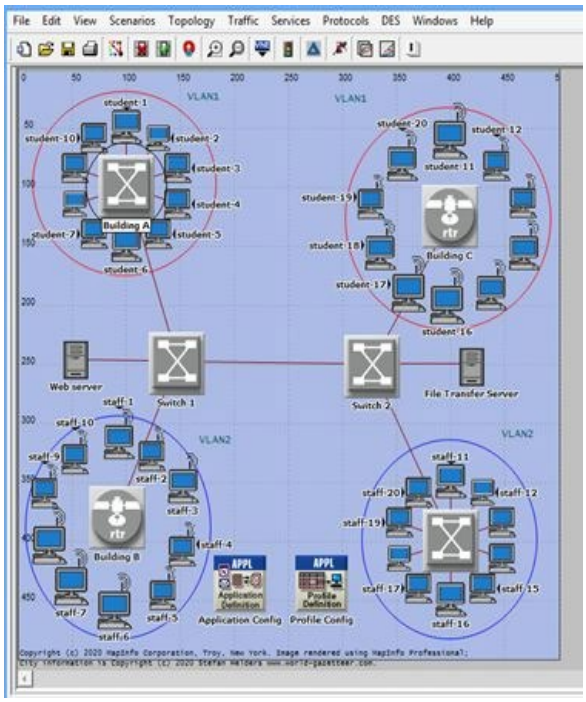

Figure 1. Baseline servers with No-VLAN

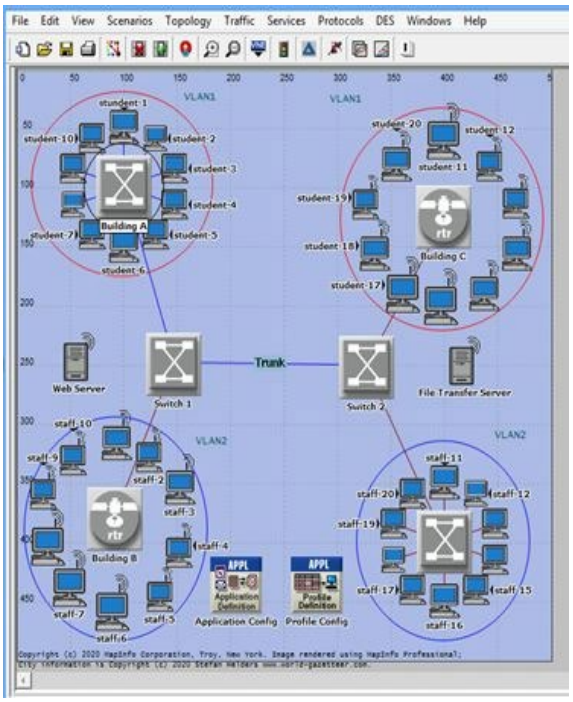

Figure 2. Depicts VLAN with wireless servers

Buildings A and D are using an Ethernet protocol to connect the users, but buildings B and C support a Wi-Fi technology of release 802.11g. The baseline project has a single broadcast domain in both wire and wireless buildings. The VLAN protocol works to divide the single broadcasting domain into a number of VLANs through the VLAN port in the switch, which provides the trunk channel to pass the tag's packets. As mentioned, the VLAN scenarios divide the users into two groups which are staff and students. As a result, the large single broadcast domain is divided into two broadcast domains. The VLAN configuration groups are set as follows: students are combined in VLAN1 that specified by red color and its VLAN ID is 10; While, the staff is gathered in VLAN2 that characterized by blue color, and its VLAN ID is 20.

3. RESULTS AND DISCUSSIONS

A new heterogeneous network model has been introduced with wire and wireless coverage areas using ethernet and WLAN technologies. When the design of the campus network has been completed using the OPNET modeler, it has been executed for fifteen minutes as a simulation time. Outcomes have been collected for the four scenarios in terms of delay and throughput (as shown in Figures 3-10). Figure 3, Figure 5, Figure 7, and Figure 9 show delays in building 1, building 2, building 3, and building 4, respectively for four scenarios. The results in these figures, state that scenarios with VLAN technology have lower delays than other scenarios with No-VLAN technology.

Also, the results, in Figure 3 and Figure 9 which represent the delays in buildings A and D, show that the delays in scenarios with No-VLAN are almost similar (as stated in green and blue curved lines). This happens because workstations in buildings A and D are connected using wires and switches. However, in Figure 5 and Figure 7 which represent the delays in buildings B and C, there are clear differences in values of delays in scenarios with No-VLAN (as stated in green and blue curved lines). Actually, workstations in buildings B and C are connected using WLAN networks that involve access points. As stated in the above introduction, the data transfer speed in WLAN is less than the data transfer speed in Ethernet wires. So, the values of delay are the highest when WLAN networks are used with wireless servers along with No-VLAN.

On the other hand, when VLAN technology is applied, it is noticed that there are no significant differences in the values of delay in all buildings. This means that using VLAN technology reduces the effect of WLAN networks in terms of delay and makes their values almost similar. In addition, VLAN technology generally decreases values of delay regardless of the way of connection between servers and workstations. Consequently, this allows taking benefits of wireless networks that are mentioned before such as easy and fast installation and configuration.

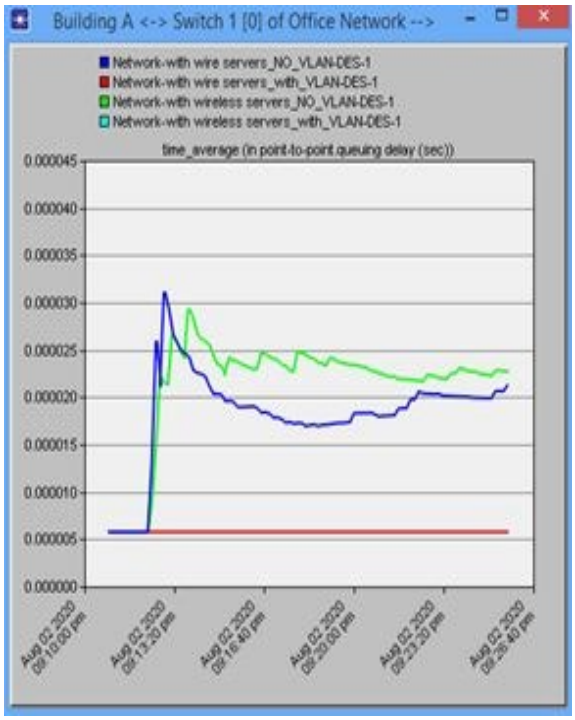

Figure 3. Delay in building A

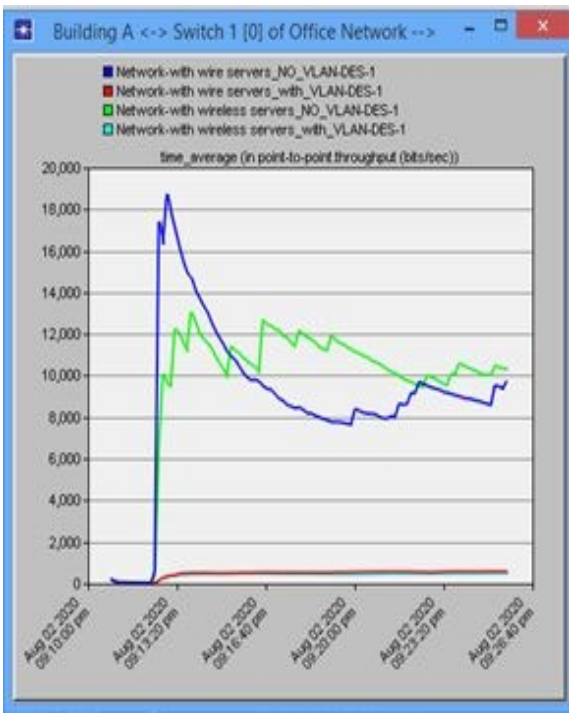

Figure 4. Throughput in building A

In Figure 4, Figure 6, Figure 8, and Figure 10 throughput curves have been displayed for building 1, building 2, building 3, and building 4 respectively for all scenarios. The results of these figures determine that scenarios with VLAN technology have lower throughput than other scenarios with No-VLAN technology. This happens because VLAN technology converts the high broadcast traffic into several domains of the small broadcast which reduces the unnecessary traffic in the network by sending traffic just between devices that are joined to a similar VLAN. As mentioned, when the traffic decreases, this increases security and improves the bandwidth.

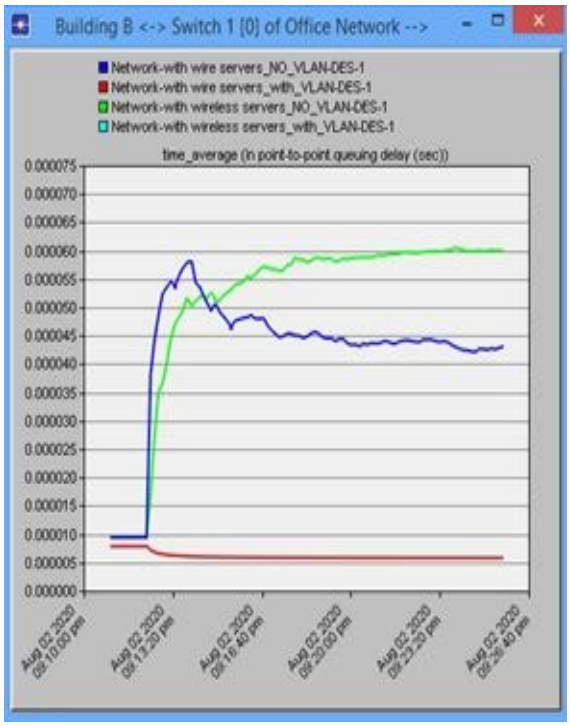

Figure 5. Delay in building B

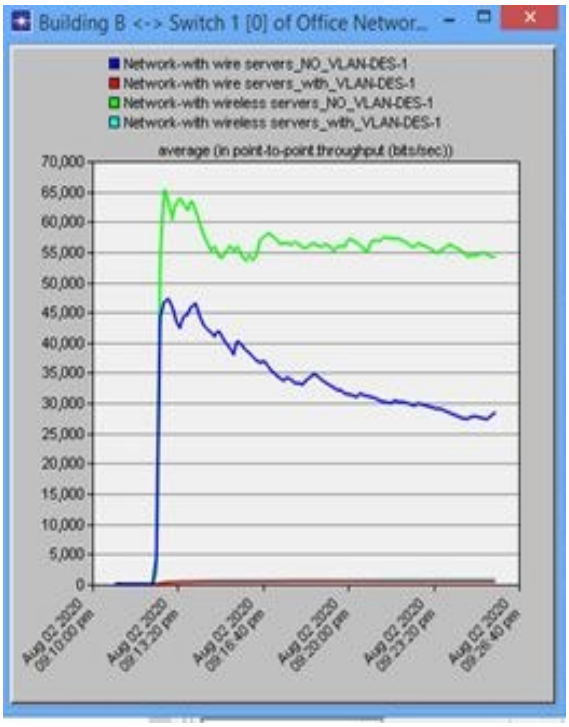

Figure 6. Throughput in building B

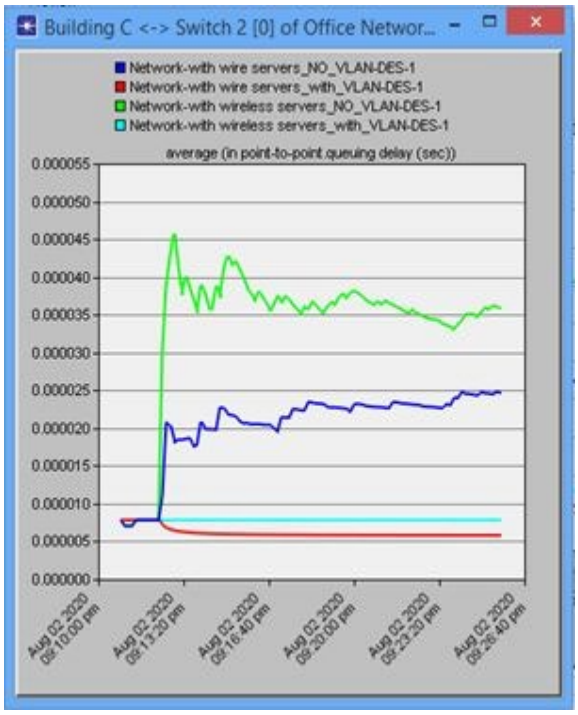

Figure 7. Delay in building C

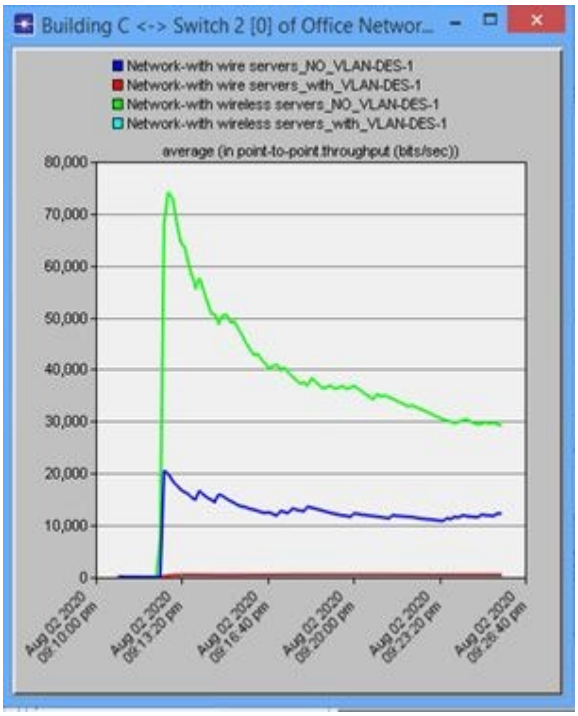

Figure 8. Throughput in building C

Also, the results, in Figure 4 and Figure 10 which represent the throughput in buildings A and D, show that the throughput in scenarios with No-VLAN is almost similar (as stated in green and blue curved lines). This happens because workstations in buildings A and D are connected using wires and switches. However, in Figures 6 and 8 which represent the throughput in buildings B and C, there are clear differences

in values of throughput in scenarios with No-VLAN (as stated in green and blue curved lines). Actually, workstations in buildings B and C are connected using WLAN networks that involve access points. The speed of transferring data in WLAN is less than that speed using wires. So, the values of throughput are the highest when WLAN networks are used with wireless servers along with No-VLAN.

On the other hand, when VLAN technology is involved, it is noticed that there are no significant differences in the values of throughput in all buildings. This means that using VLAN technology reduces the effect of WLAN networks in terms of throughput and makes their values almost similar. In addition, VLAN technology generally decreases values of throughput regardless of the way of connection between servers and workstations. This, in turn, allows taking benefits of wireless networks that are mentioned above such as the flexibility and speed in achieving the infrastructure of required networks.

The results also determine that a high-power efficiency has been achieved by reducing the broadcast domain, in addition to the above features of VLAN scenarios that have been accomplished in terms of delay and throughput. As a result, all these features, in turn, improve the bandwidth utilization which results from reducing the broadcast domain. Furthermore, a small broadcasting domain means less potential to be attacked. Finally, VLAN with wireless servers' scenarios presents significant improvements in terms of delay, throughput, bandwidth utilization, power efficiency, and security. These features are combined with the benefits of using wireless communication systems.

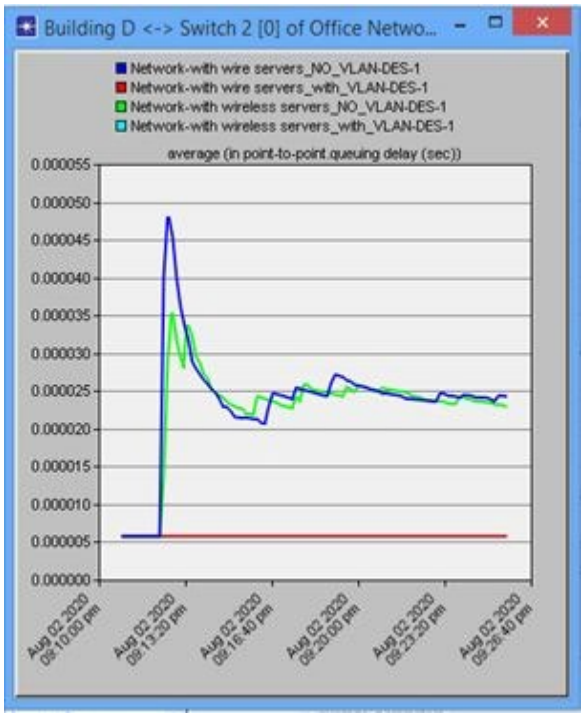

Figure 9. Delay in building D

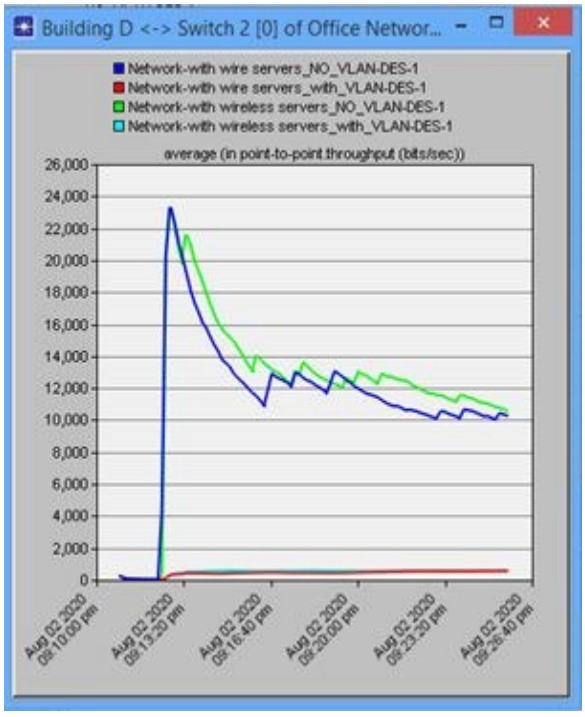

Figure 10. Throughput in building D

4. CONCLUSION

World countries have started using modern technology to reduce health, economic, and educational risks. The increased demand for modern technology increases the burden on the LAN network. This paper presents four scenarios with different technologies which are LAN (No-VLAN) and VLAN, baseline server, and broadband wireless servers, which are analyzed and investigated. The simulation model has four different buildings with two logical groups of users using two network applications which are FTP and web browsing applications. The simulation has been carried out by using the OPNET. Security, network expansion, and accessibility have been taken into considerations. The simulation results show that VLAN technology overcomes the LAN network in terms of delay and throughput. It is proven that the VLAN network has fewer throughputs in both transmitting and receiving to the confidential servers. Moreover, VLAN technology has a lower delay than the LAN network. This, in turn, improves QoS which positively affects the performance of the campus network in terms of bandwidth utilization, power efficiency, and

security. In the future, other applications can be considered to test the performance of the network. Also, the VLAN design can be examined with wireless access points by using different Ad-hoc routing protocols.

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