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A Proposed Design of Campus IP Network for Duhok University Using OPNET

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ABSTRACT

Duhok University has two main campuses. The first is the Malta campus located at the western part of the city and consists of seven colleges. The second one is the Duhok center which is located in the city center, it comprises six colleges in addition to the university chancellor office. This research paper proposes a network design for Duhok University to enable student and academic staff exchanges their academic and administrative information efficiently. The proposed IP Network design is made of three layers of which the core layer consists of two Cisco SONET 12012 which is connected by dual links. One of the SONETs is assigned to the Malta Campus and the other to Duhok center campus. The minimum spanning tree is calculated for the proposed IP network by using real distances between university colleges. At the distribution layer, a hierarchical topology is used to connect the college campus to its nearest main campus. The network is attached to the two main FTP and HTTP servers. The data stream of each college is forwarded to Cisco router 4700. The user layer in each department is implemented using star topology through a Cisco switch 2924. Mobility access is added to the proposed design to support wireless devices. The design is implemented using OPNET 14.5 modular. Network performance and server's quality are tested by calculating (packet/second), delays, traffic send, traffic receives utility, and throughput in case of heavy load the network performance and server's quality. The results show that the proposed Duhok University IP network fulfills the network requirements and future expansion.

Keywords: IP-Networks, Cisco, Minimum Spanning tree, OPNET

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تصمصم مقترح لشبكة IP لجامعة دهوك باستخدام OPNET

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الملخص

جامعة دهوك لديها حرمين جامعيين. الأول هو حرم مالطا الواقع في الجزء الغربي من المدينة ويتكون من سبع كليات. والثاني هو مركز دهوك الموجود في المدينة. وهي تضم ست كليات بالإضافة إلى مكتب الجامعة. تقترح ورقة البحث هذه تصميم شبكة جامعة دهوك لتمكين الطلاب والأكاديميين من تبادل المعلومات الأكاديمية والإدارية بكفاءة. يتكون تصميم شبكة IP المقترحة من ثلاث طبقات تتكون الطبقة الأساسية منها من اثنين من Cisco SONET 12012 متصل بواسطة روابط ثنائية. تم تعيين واحد من SONETs إلى الحرم الاول في مالطة والآخر إلى الحرم الجامعي الرئيسي في دهوك. تم حساب الحد الأدنى لشجرة التوزيع لشبكة IP المقترحة من خلال استخدام المسافات الحقيقية بين كليات الجامعة. في طبقة التوزيع ، تم استخدام طوبولوجيا هرمية لتوصيل حرم الكلية إلى أقرب حرمها الرئيسي. تم إرفاق الشبكة بخادمي FTP و HTTP الرئيسيين. تم توجيه دفق البيانات لكل كلية إلى موجه Cisco 4700. تم تنفيذ طبقة المستخدم في كل قسم باستخدام طبولوجيا النجوم من خلال مفتاح Cisco 2924. إضافة للتصميم المقترح دعم الأجهزة اللاسلكية. نفذ التصميم المقدم باستخدام برنامج OPNET 14.5. اختبر أداء الشبكة وجودة الخادم من خلال حساب (الحزمة / الثانية) ، والتأخير ، وإرسال حركة المرور ، واستلام حركة المرور ، والإنتاجية في حالة التحميل الثقيل لأداء الشبكة وجودة الخادم. وأظهرت النتائج أن شبكة IP في جامعة دهوك المقترحة تلبي متطلبات الشبكة والتوسع المستقبلي.

الكلمات الدالة: الحد انى للشجرة الممتدة, Cisco, P–Network, OPNET

1. Introduction

Information technology is important to sustain the progress and facilitate task implementation in business and academic enterprises. Universities encounter increasing challenges to provide faster communication services and enhance the individual's capabilities and skills. University IP-Network helps universities to be more collaborative centers. It helps them achieve and implement efficient academic programs. There are four important components in the proposed architecture, which are: Services like HTTP protocol, Network Control, Core Switching and Edge Access [1]. The present research proposes an easily upgraded, reliable and robust design for Duhok University campus Duhok University. It is also possible for the model to be expanded in case of an increase in the number of colleges which eventually leads to an increase in the number of students and staff. The Minimum Spanning Tree (MST) is calculated for the proposed network based on real distances between colleges and university to minimize the costs of additional links. Duhok university campus is divided into three layers: the access, distribution and core layers respectively with the core network layer providing the backbone for the network while the distribution layer aggregates multiple technologies from the access layer. Many kinds of research and projects have been conducted to network modeling, simulation, and verification: Junaid Ahmed Zubairi et al [2]. Their proposed campus design has recently shifted to switched Ethernet subnets and Gigabit Ethernet backbone and has studied the performance of the time-sensitive applications on campus network under varying load conditions using OPNET. A model of SUNY Fredonia university campus network was developed in OPNET. The Ethernet delay, traffic statistics, and other interesting data were calculated and a new innovative algorithm for handling real-time speech traffic over the existing IPv4 network was tested via OPNET simulation. Theunis et al [3] came up with an OPNET based design for the educational network which led to an improvement in the practical skills of future network engineers. V. Hnatyshin et al [4], examined the student and faculty usage of network applications and their impact on the Rowan university network design model. D. Akbas [5], on the other hand, studied the influence of Firewall and VPN (Virtual Private Network) on typical enterprise network performance. Thus both the real

enterprise network prototype and virtual OPNET simulation models were constructed and compared. Ibikunle Frank et al[6]proposed a means of improving campus network performance by presenting a network model based on Multiprotocol Label Switching-Virtual Private Networks (MPLS-VPNS), a technique basically used by network service providers. Tush et al, [7] used many routing and switching protocols like OSPF, BGP, EIGRP, STP, HSRP, VTP, to design industry standard hierarchical layout of a campus network. Malek N. Algabri et al [8] presented two scenarios for designing a campus network for Sanaa University which was in lack for efficient campus network which would connect its remote campuses such as Arhab, Mahaweet, Khawlan, Medicine colleges, and the Old University campus. The first scenario is based on IPV6 protocol over MPLS and the second one is based on IPV6. protocol over MPLS -VPN techniques. Dhirendra Sharma et al, [9] presented a campus network design for six universities in the Western Himalayan region of India with three phases. In the first, the efficiency of different campus networks was calculated. In the second phase is data handling capacity per user in the networks was calculated in terms of network throughput of core-switch. then the segment/ component- wise efficiency for the real network system was found. Agueda Sofia Tavares, [10] studied reference model architecture of the university campus network in China that could be followed or adapted to build a robust yet flexible network. Bagus Mulyawan et al, [11] presented an IP-network design for the campus of Tarumanagara University based on the hierarchical structure at the core layer with redundant devices at both the distribution and access layers. Baek-Young Choi et al. [12] Made failure analysis of a university campus network using a huge set of both node outage and link failure data. Modhar A. Hammoudi [13] also built a model for Mosul University campus made up of two routers cisco 2600, core switch, Cisco 6509, two servers with IP32 cloud, and 37 VLANs. He discussed the application of VoIP on the proposed design. Meanwhile, Potemans et al, [14] proposed a student network design project for the Katholieke Universiteit Leuven with the VoIP services. B. Rodgers, [15], on their part, built a model with ring-like SONET backbone at the K.U. Leuven University in Belgium.

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2. Theory

The suggested model for Duhok University IP-network is initiated by selecting a suitable network layout which is a very important factor to be considered in endpoints (nodes) connection via communication lines

The objective is to find the least network connection cost. Such problems can be handled by constructing the minimum spanning tree throughout the network. The prim algorithm [16]: can be used to solve this problem. The Prims Algorithm is described by the pseudo code below:

Algorithm 1 Prime's Algorithm

Input:A weighted connected graph G with n vertices and m edges
G with n vertices and m edges
Output: A minimum spanning tree T for G
Q = new heap-based priority queue
s = a vertex of G pick up any vertex s of G
Initialize T to null
$\forall$[v]$\in G.vertices()$
if $(v = s)$ **then**
  setDistance(v, 0) set the key to zero
else
  setDistance(v, ∞)
  setParent(v, ϕ)parent edge of each vertex is null
end if
Initialize the Q with an item (u,null), $D[u]$ for each vertex u where (u,null) is the element and $D[u]$ is the key.
D[u] is the distance of u
while $\neg Q.isEmpty()$ **do**
  $(u, e) \leftarrow [Q.removeMin()]$
  Add vertex u and edge e to T
  $\forall$[e]$\in G.incidentEdges(u)$
  $z \leftarrow$G.opposite(u,e)
  for each vertex z adjacent to u such that z is in Q
  $r \leftarrow weight(e)$ $[= w(u, z)]$
  if $r < getDistance$(z) **then**
    setDistance(z,r)update the$D[z]$ in Q
    setParent(z,e)update the parent of z in Q
  end if
end while
return the tree T

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The resultant minimum spanning tree of the proposed IP-is depicted network is illustrated in the (see figure1), where the distances marked between colleges are real. Java applet is used to construct the minimum spanning tree in which the blue and red lines indicate the shortest paths with each link marking the distance. The gray lines indicate the canceled links while the red lines indicate that the college is connected via a single path, as is the case with the colleges of science, medicine, and dentistry. In proposed design required the technical institutes are also included. The design should be expanded so as to include all academic institutions in Duhok city. (Fig2) shows the distribution of Duhok university colleges in both campuses (Malta and Duhok-center) based on the real map. In the design, a SONET for each campus is dedicated.

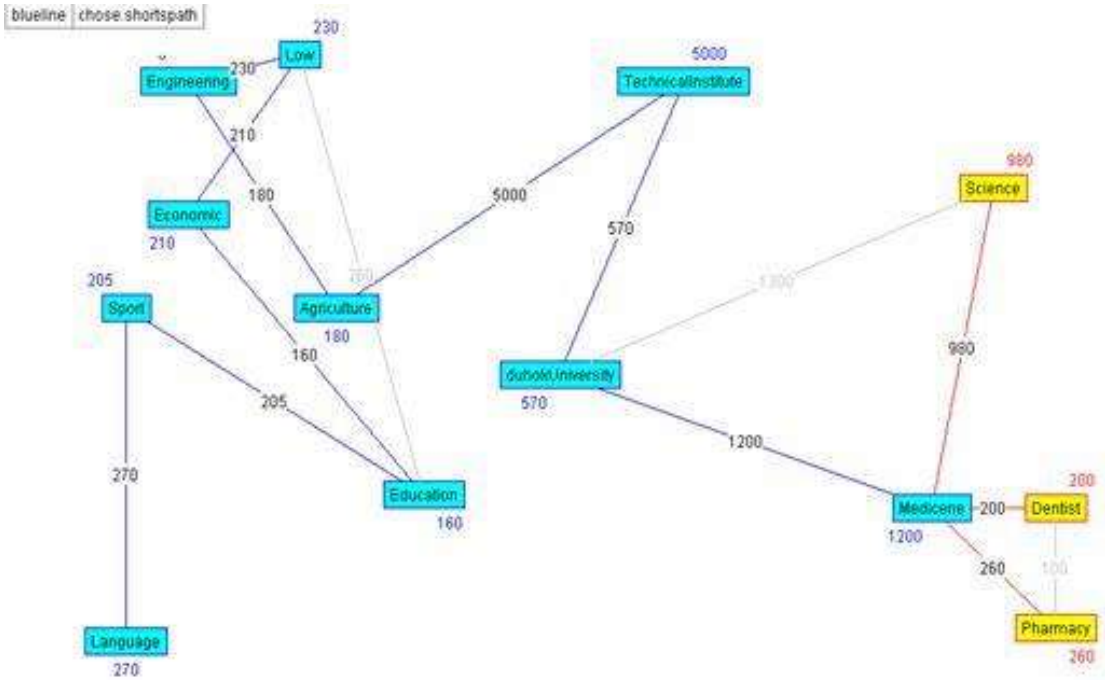

Fig. 1. The prim algorithm on the backbone.

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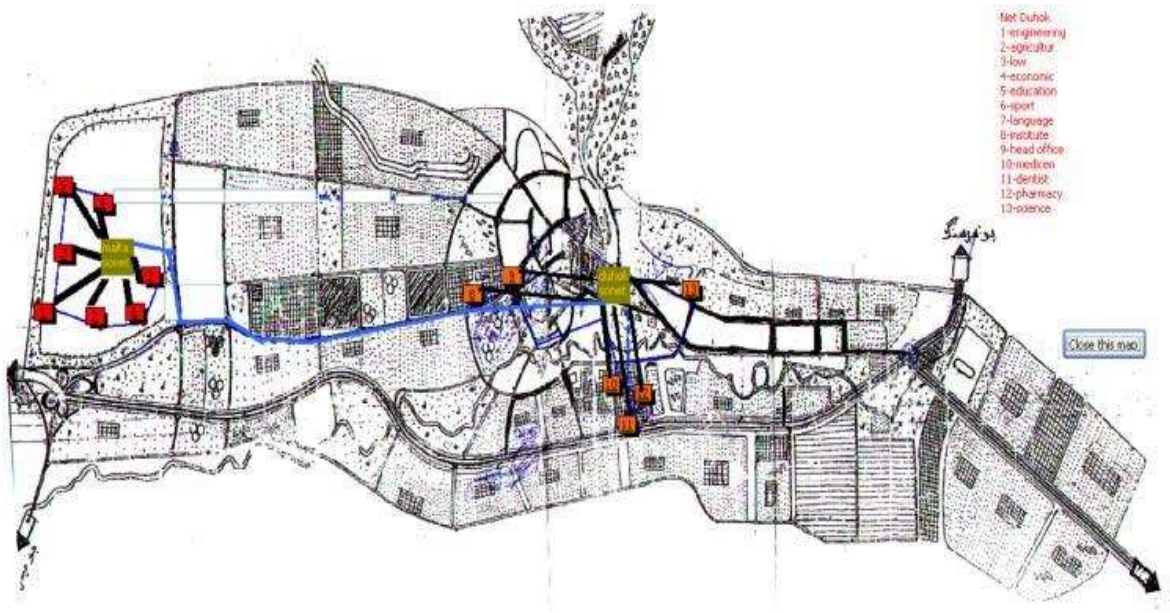

Fig. 2. Marking colleges and campuses on a real map of Duhok city.

The proposed design at the core layer is illustrated in fig 3. The university two sub-campuses are connected to Cisco SONET of type 12012 individually, then both of the SONETs are mounted in a ring-like topology to the PopSONET7650 this device can be used in case of network future extension or expansion of the proposed design. Dual Ring topology based DWDM (Dense Wavelength division multiplexing) is used in this layer to interconnect devices using the optical cable of type OC-48 with transmission speed up to 2488.32 Mbit/s (payload: 2405.376 Mbit/s (2.405376 Gbit/s); overhead: 82.944 Mbit/s) [17].

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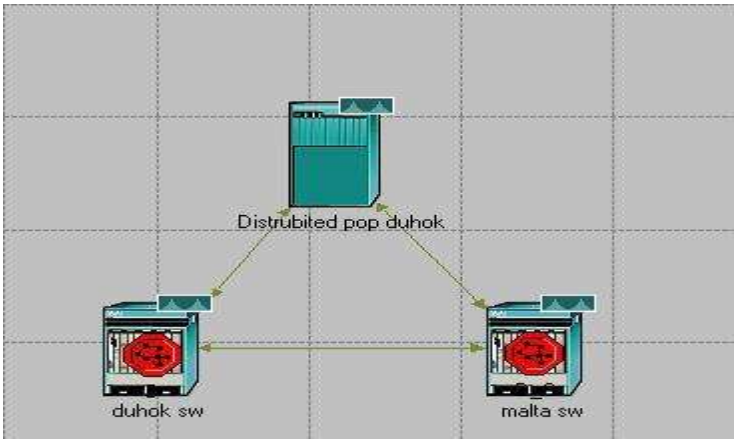

Fig. 3. Core layer for Duhok University IP-Network.

Figure 4 shows the Distribution layers for Duhok University IP-Network. A group of Cisco access points of type 4700 is used to connect each college access point to the nearest SONET. The network topology at this level is hybrid topology between (bus and star) typologies each college access point is connected through dedicated optical link of type OC-12 to the nearest campus center, which ensure a transmission speeds of up to 622.08 Mbit/s (payload: 601.344 Mbit/s; overhead: 20.736 Mbit/s)[17]. The bus topology can be seen between colleges access points this type of connection increases the cost with the benefit of increasing network reliability and availability. Hence any failure may happen at any direct link of the SONET the auxiliary line with the nearest college can replace it such that the data stream can be directed to the SONET through this auxiliary link then after through college dedicated link. Two data servers were attached to the proposed network the FTP-server and HTTP server.

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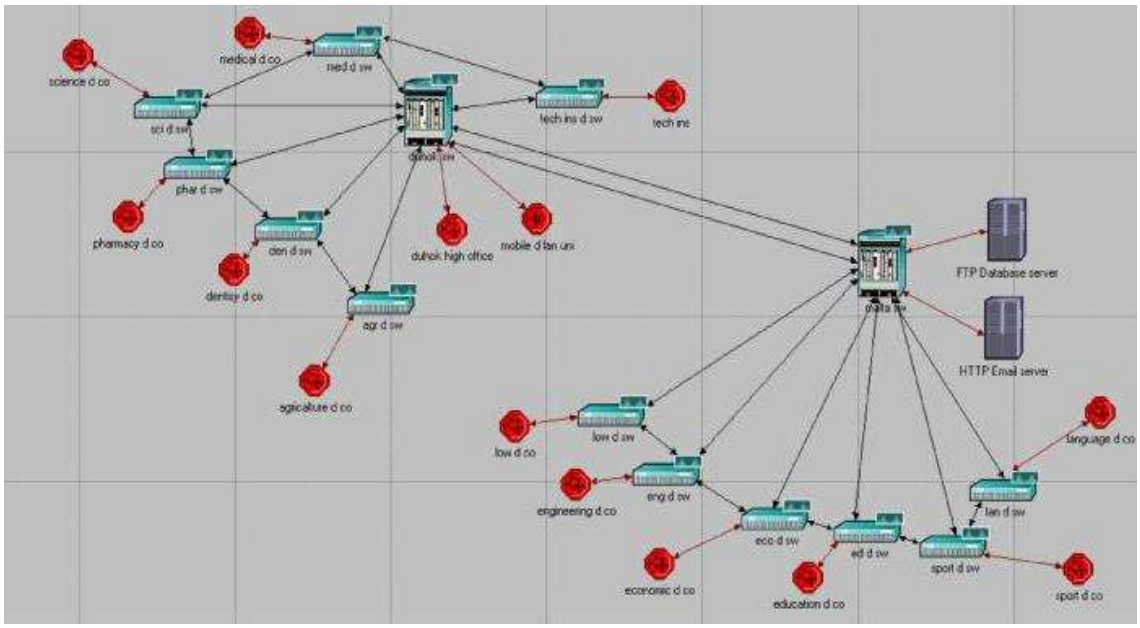

Fig. 4. Core and Distribution layers for Duhok University IP-Network

For the campus of Duhok center, two additional networks were added the mobile network and the chancellor and university administrative network, to facilitate the job of university admiration. The mobile network is depicted in fig5 below:

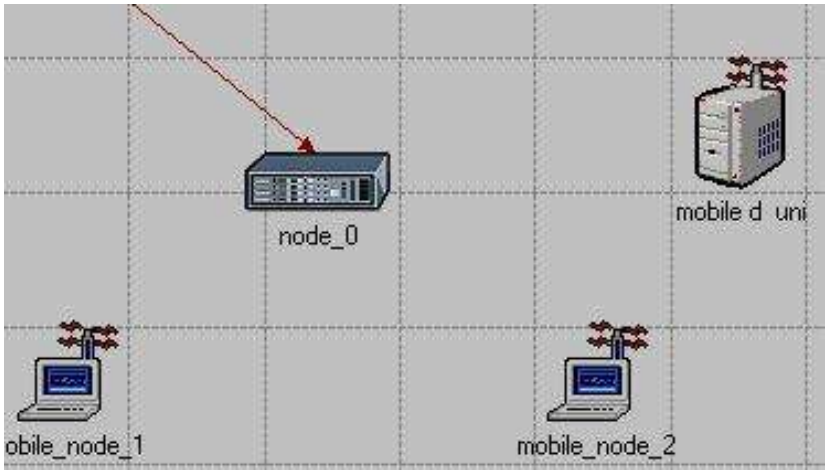

Fig. 5. Mobility server of Duhok University IP-Network

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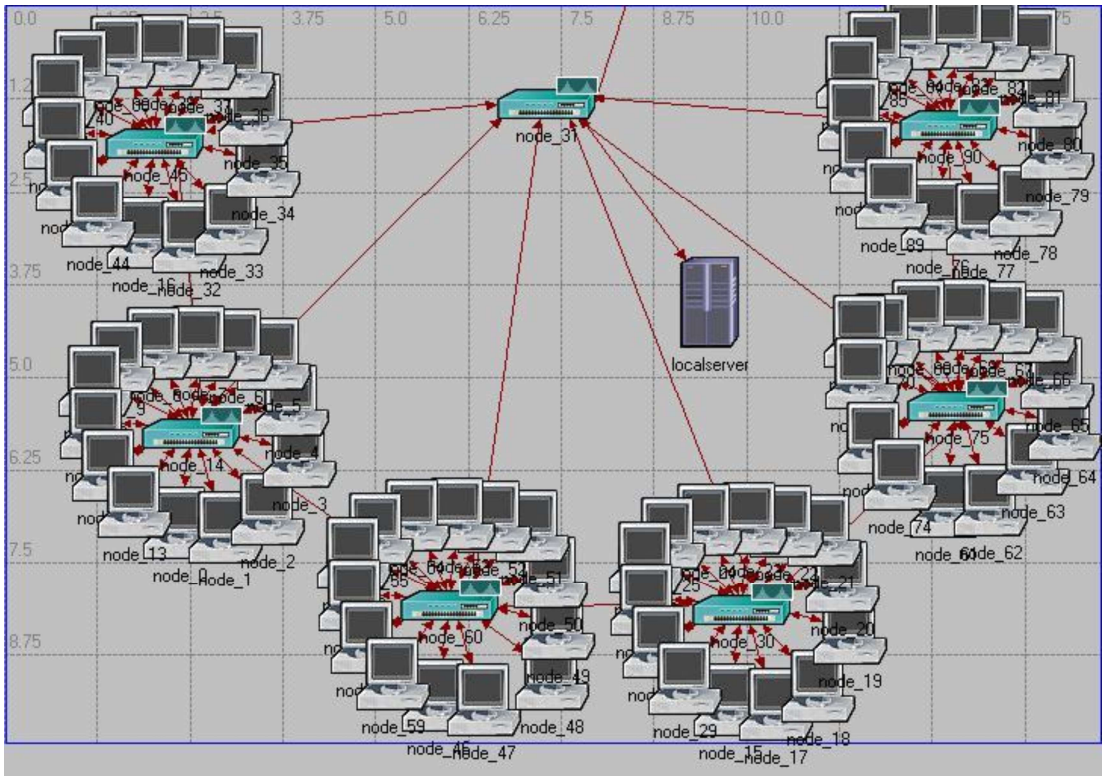

Fig. 6. One college LAN Heretical design for Duhok University IP-Network.

3. Results and Calculations

This section presents the performance of the proposed model by calculating the standard statistics monitoring characteristics such as bit error rate or delay and throughput.

A. Mobility server client simulation

The mobility server load, server traffic sends, server traffic received, and task processing time for HTTP protocol are illustrated in fig7. The first three quantities were measured in Byte/seconds, while the last quantity is measured in second. It is clear that the maximum task processing time is about 0.006 sec.

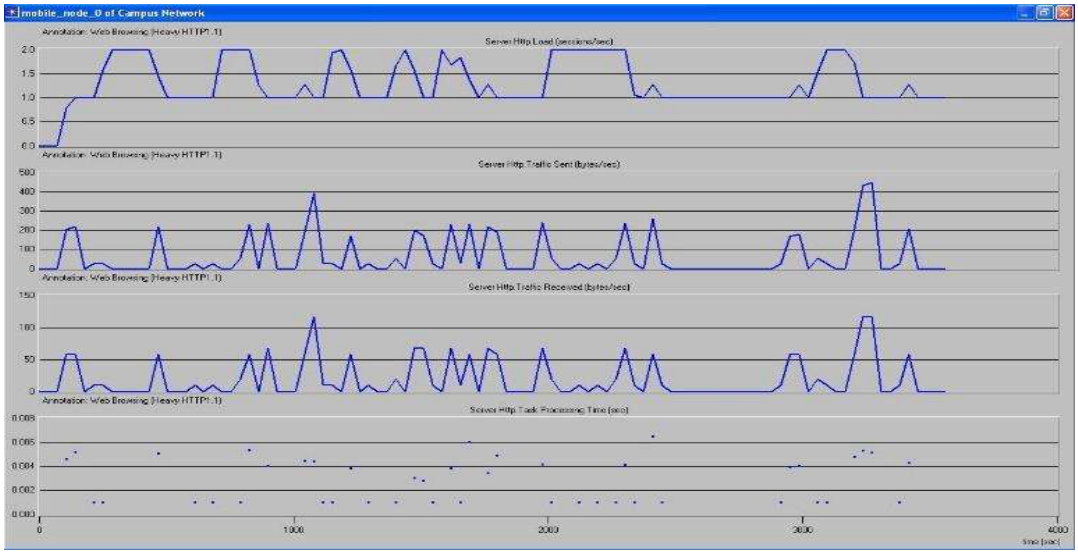

Fig. 7. Mobility server statistical results.

In another place, the average server task processing time is about 2825 sec. The TCP connection aborts, TCP delay, and TCP retransmission for mobility are illustrated in fig8. The maximum TCP delay is 0.045 msec whereas the maximum re-transmission during the simulation time is 7msec.

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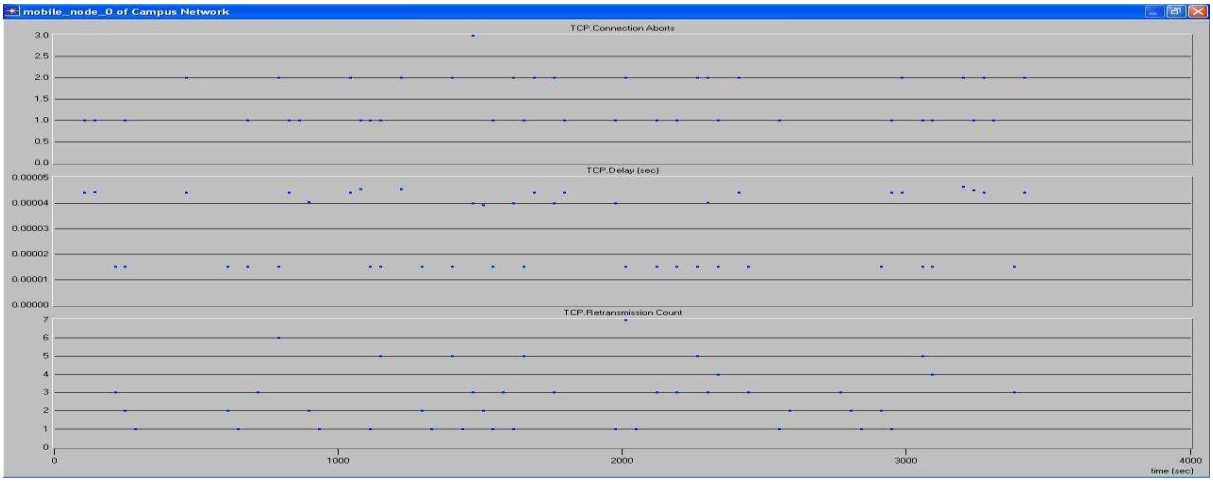

Fig. 8. Mobility TCP Task Network.

B. Ethernet Network Statistical Measurements

The simulation results for the local Ethernet server contains the point-to-point queuing delay, server task, and server HTTP application loading and task processing. All these measurements were computed during a 4000sec network operating time. fig.9 describes server HTTP task in this figure the server HTTP load is given in session/second while the server HTTP task processing time with TCP delay is in second. There is the time of halting starts after the sec 900 until approximately 2500th sec in which the server received no load. It is clear that the maximum TCP delay is about 0.0004sec.

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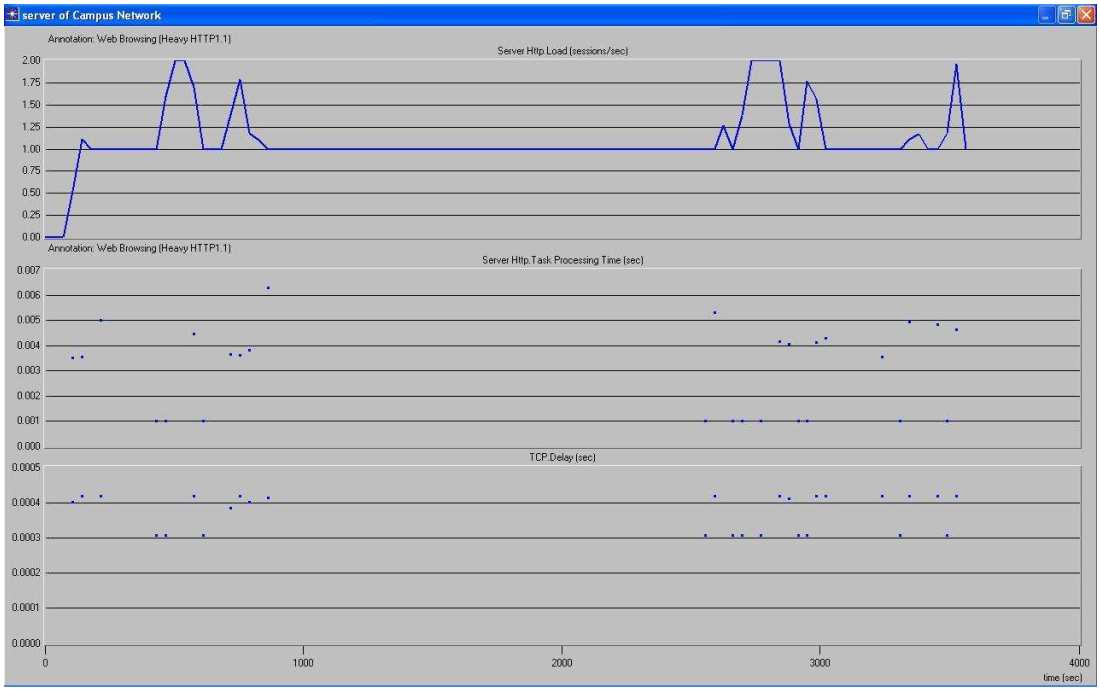

Fig. 9. HTTP server tasks

In fig.10 the point-to-point task analysis provides the queuing delay received and transmitted with received and transmitted throughput: also, a very short queuing delay between transmitted and received was detected (about 3.93 sec queuing delay difference is detected between sender and receiver points). There are two scenarios in designing campus level network. The first scenario is to connect different LANs with hubs and connect these child hubs to the parent access point. The other one depends on the child switches connected to the parent access point.

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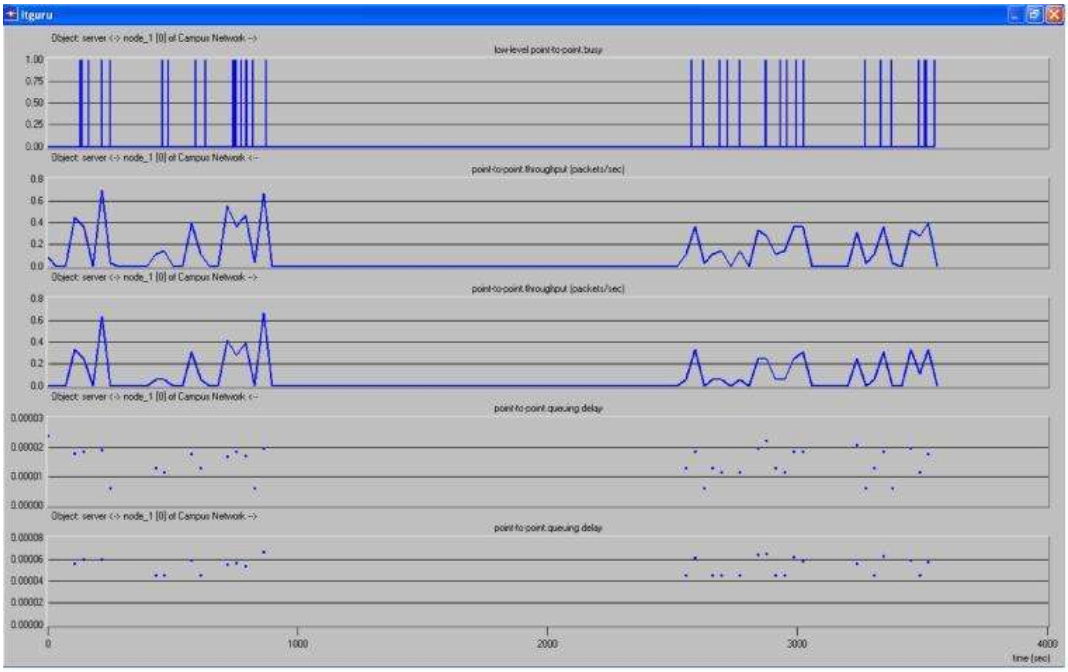

Fig. 10 Point-to-point task analyses.

To investigate the advantages of each of the proposed scenarios using OPNET package network performance is calculated in term of point to point throughput between two extreme points in campus network as illustrated in fig.11, in this figure it is clear that the throughput of hub-based design is higher than switch-based design and that led to reduce network performance and increase network utilization. The switch-based network has an average throughput of 0.031945 packet/sec with a max of 0.111 packet/sec, while in the hub-based network the average throughput is 1.6833 packet/sec with a max of 3.8889 packet/sec. Hence, the throughput increases in the hub-based network as compared to a switch-based network in spite of the fact that the delay in the first scenario is reduced. The Ethernet load (bit/sec) on campus network based on switch and hub is plotted in fig.12 for 4000 sec of network operation.

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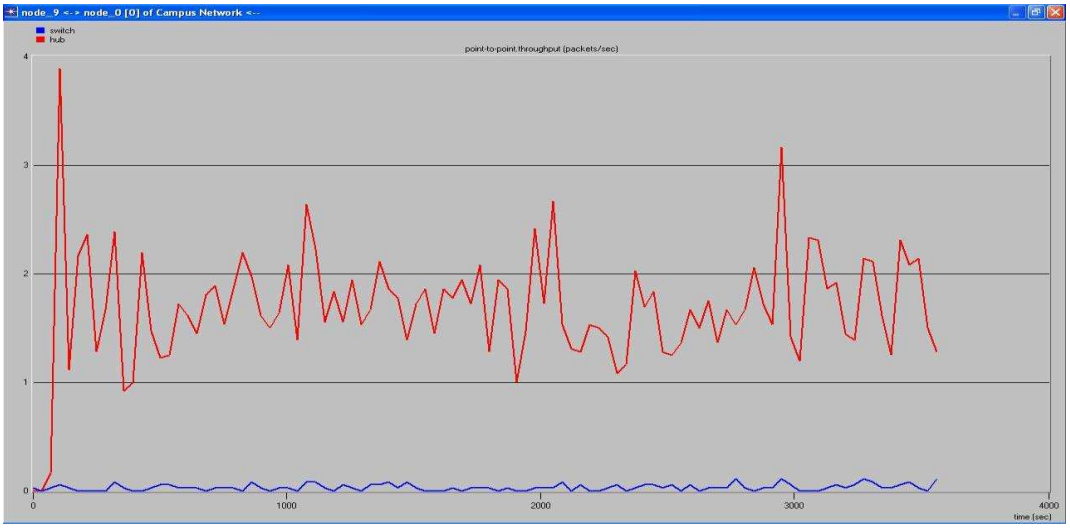

Fig. 11. Point to point throughput plotting.

Ethernet load for the switch-based network is averaged on 97.89 bit/sec with a peak of 394bit/sec. While in hub-based a campus, the average is 104.507 bit/sec with a peak of 657.778 bit/sec which means employing hub reduces the network performance approximatel to half.

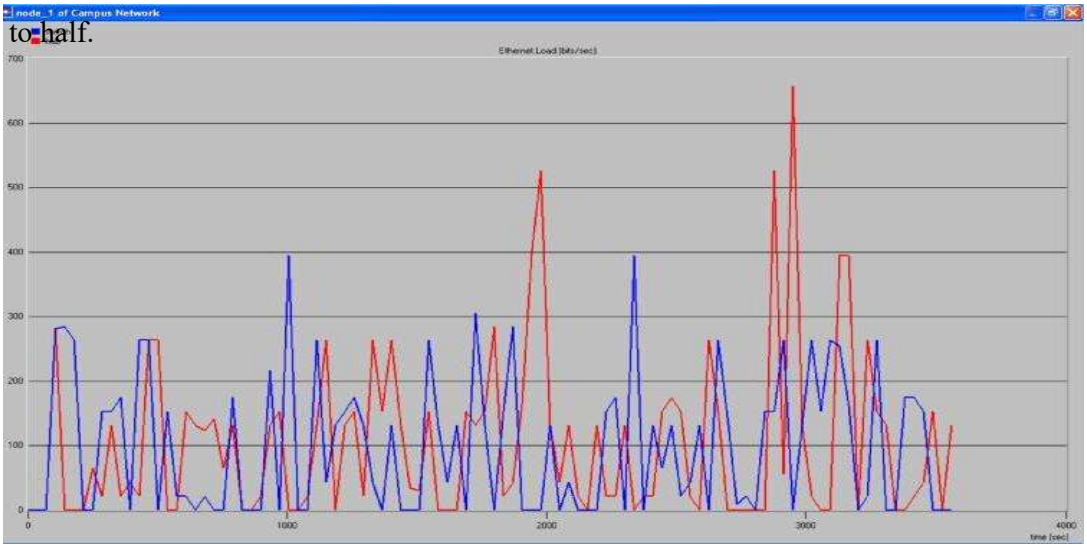

Fig. 12. Point to point throughput plotting

For comparison, the proposed Network utilizes network presented in [15] for K.U.L in Queuing delay by about (246 sec) due to employing optical technology (SONET).

4. CONCLUSIONS

The performance results for the proposed Duhok University IP-network using OPNET package showed that the proposed design can fit multimedia transmission and (voice over IP) because of its high reliability and its low delay due to its dependency on the optical communication technology and proposed hybrid and hierarchical typologies The proposed design takes into consideration the future expansion in the university atmosphere when the scientific establishment and institution numbers I expands both horizontally and vertically As depicted in simulation results, the switch utilized hub and improved the network performance by reducing delay, load, and throughput. Employing hub reduces the network performance approximately to half. The increment in Ethernet delay using switch can tolerate in term of increasing reliability.

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