ENHANCING SERVICES IN HEALTHCARE SYSTEM USING OVERLAPPING NETWORK MODELS

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ABSTRACT

Currently, the wireless technology is widely used and also played an important role due to its comfort and portability. Users can easily access this technology from anywhere through access points. So, this paper proposes an alternative solution to enhance the performance of a core network as well as solving congestion and long delay time problems. The proposed solution is an installation of the wireless network over a wired, and also applying with the suitable policy in each network. Additionally, in the high traffic load, the results have shown that the model of wired with Wi-Fi including a good management policy can achieve the highest performance in reducing loss rate, while efficiently reserved the minimum loss rate and average end-to-end delay in both of the middle and the highest priority departments which involve in information significantly in vital. Additionally, installation of the wireless technology also supports portability and convenience for doctors and staffs within the hospital. Thus, they can use Wi-Fi devices from anywhere in the hospital to help them diagnose, update the significant information, or even access the e-service while obtaining the minimum delay time.

Index Terms— policy, services, overlapping network, throughput, delay

1. INTRODUCTION

Hospital services are very important, and sometimes significant in vital. This is required for appropriate organization within the system. Currently, many healthcare organizations install a wired network as their core network for serving the network utilization in their organizations. In contrast, people tend to use wireless technology increasingly due to its comfort, and portability. For that reason, some healthcare organizations introduce a wireless technology to their organization for serving the need of their users, and supporting some responsibilities in their organizations. Additionally, [1] mentioned that the policy also plays an important role in other areas of network management, including configuration, accounting, fault, and performance management. Furthermore, the result from [2] has shown that the hybrid network has higher efficiency than the network implemented in either cable or wireless located at the rural area. As the fact that most networks are heterogeneous, the management policy must be determined differently from a homogeneous network in order to obtain its efficiency and high performance. Thus, an integrated network management architecture for managing heterogeneous networks using an application program interface and lower layer manager has been proposed by [3] in the year 2000. Besides, the QoS of the service-oriented monitoring framework is also an important issue to be considered to protect any undesired situations. Thus, [4] proposed a service oriented monitoring framework inside wired and wireless access/core networks to control and guarantee the QoS between service providers and users. Since [5] have realized an important of network policy for managing all the resource within the heterogeneous network properly, they proposed a toolkit for intelligent management of resource allocation in heterogeneous network infrastructures based on policies of different actors (network operator, service providers and users).

This paper is organized as follows. In Section 2 introduces the current architecture of Healthcare system followed by stating the problem in Section 3. Then, the proposed solution for this problem is in Section 4. After that, the simulation model and results are described in Section 5. Finally, conclusions are drawn in Section 6.

2. CURRENT ARCHITECTURE

In this architecture, the hospital consists of 2 buildings: Inpatient building, and Outpatient Building. The core network is a gigabit Ethernet. For the Inpatient, it contains 9 fundamental departments, which are Emergency room, Intensive Care Unit, Radiology, Operating Theatres, Labour Delivery, Anaesthesia, Inpatient 1, Inpatient 2, and Server. For the Outpatient building, it contains 7 fundamental departments, which are medical record, pharmacy, Ear Nose Throat (ENT) clinic, Musculo-Skeletal Clinic, Dental Clinic, Laboratory, and Server. All departments will connect to the server for receiving information used in the building.

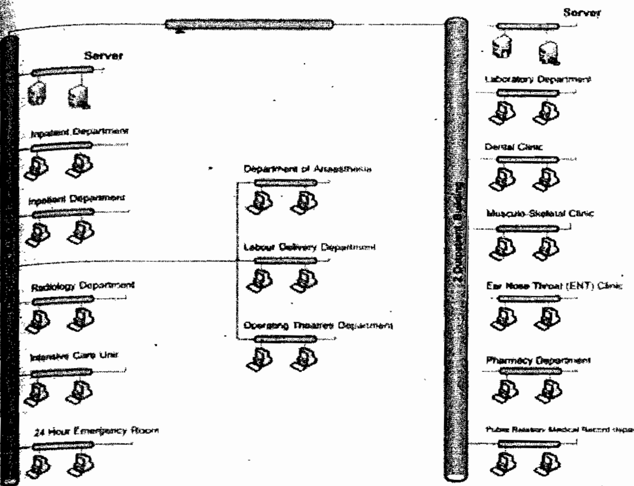

Figure 1. The current network architecture of Healthcare system

3. STATE OF PROBLEM

Due to various kinds of services and applications served for several purposes within the network, congestion can occur. As a result, incoming information may delay in some situations. In contrast, hospital services are sometimes significantly in vital so this problem can be a serious one in some emergency cases. Consequently, network administrators will solve this problem by creating a new performance network system, or expanding a core network. In doing so, they will expand a cabling system. Although they can obtain a reliable authentication and authorization of their information, it will cost a lot of money and implementation time. Furthermore, the old network system must be terminated and replaced by the new one iteratively. Furthermore, there is no suitable managing in their applications that is transmitted from the departments and must be routed over the entire network.

4. PROPOSED SOLUTION

Therefore, we proposed an alternative architecture to solve the increasing congestion and delay time. The alternative architecture is the installation of a wireless network over a wired network in order to relieving congestion. Thus, the organization will have a wired as a core network to achieve the main purpose of their hospital with a capability of authentication and authorization, and also have a wireless network, which excludes for the core network, as an alternative network to provide minor purpose of their hospital, such as Internet services for their patients. Additionally, applications in this system are managed by setting up the policy for reducing the delay time in some significant departments. In this research, the wired policy was determined differently from the Wi-Fi policy in order to distinguish the important flow in each network.

Referring to the wired policy, it was set up by considering the important of each department. Thus, the highest priority for the departments which are significantly in vital is set and some tasks were required for the short delay time for an incoming message. Additionally, the middle priority for the departments is set for the tasks that required for various kinds of applications and sometimes transmit their information to doctors, if they request for it. Furthermore, setting up the lowest priority for the department which used only data in their main tasks, or tasks can be waited in this kind of department. Consequently, the policy for the wired network in the Inpatient building and Outpatient building is shown as follow:

- Highest priority: Emergency room, Operating Theatres department, Labour Delivery department, Ear Nose Throat (ENT) clinic, Musculo-Skeletal Clinic, and Dental Clinic
- Middle priority: Intensive Care Unit, Anaesthesia department, and Laboratory department
- Lowest priority: Radiology department, Inpatient 1 department, Inpatient 2 department, medical record department, and pharmacy department

Consider the wireless policy, setting up the policy for wireless network is differ from the wired network; it is because transmitted applications from the wired is the only task served for the needs of the hospital. In contrast, applications from the wireless network can be transmitted from doctors who request information for helping them diagnosis, or transmitted from the patients who would like to surf an Internet while they are waiting for doctors. Moreover, if the policy was set up by considering only the important of the department according to the wired, the applications for significant information from the lower priority departments can be blocked by the Internet applications from the higher priority departments in some cases. Therefore, the priority for Wi-Fi applications is set up by considering the objective and the type of users. Accordingly, there are 3 types of applications, which are applications from the Internet services for patients, Internet services for doctors, and patient information for doctors. If the applications are for doctors, or staffs who work in the hospital, the system requests for a password when connecting to Wi-Fi services. On the other hand, if the users are patients who would like to access the Internet using Wi-Fi services, they can connect without requesting any passwords. Thus, there are 3 flow types from Wi-Fi, and the policy for them is shown as follow:

- Highest priority: Patient information for doctors, or staffs within the hospitals.
- Middle priority: Internet service for doctors, or staffs.
- Lowest priority: Internet service for patients

5. SIMULATION MODEL DESCRIPTION AND RESULT

In this experiment, a Gigabit Ethernet is simulated as a wired network and IEEE 802.11g as an alternative network. Moreover, the service transfer type is the Constant Bit Rate (CBR), and the MAC frame size is 1024 bytes. In order to measure the performance of the network, 3 network models were compared: Wired, Wired with policy, and Wired and Wi-Fi with policy.

In wired, the simulation was performed by varying offered loads of the entire system as 750, 1000, and 1250 Mbps.

In wired with policy, the simulation was the same as the wired network model, except that it applied the policy in this model.

In wired and Wi-Fi with policy, the policy of the wired network was unchanged, but the wireless was installed as an alternative network, and also apply the wireless policy in this model. The wireless technology that is applied in this experiment is Wi-Fi (802.11g) with data rate 54 Mbps, which typical throughput of this technology is about 20 Mbps. So, in this experiment, some applications were splitted, which all have the data rate about 20 Mbps from the wired, and transmit them via Wi-Fi instead. For example, splitting 20 Mbps. of data from the entire system which have the offered loads as 750, 1000, and 1250 Mbps, so the wired network will transmit at 730, 980, and 1230 Mbps, respectively. Furthermore, splitting 20 Mbps. of the wireless network into 3 flow types: the Internet services for patients with data rate 10 Mbps, Patient Information for doctors with data rate 5 Mbps, and the Internet services for doctors with data rate 5 Mbps. The results of this experiment are described as follows.

5.1. Throughput

The measurement of the performance is considered from throughput loss rate of these 3 network models in 2 ways: the loss rate of the overall system and the loss rate of each department in the Inpatient building and Outpatient building.

5.1.1. Overall Throughput

In this experiment, throughput loss rate of the overall system was compared in 3 network models, when the offered loads of the entire system are 750, 1000, and 1250 Mbps. According to Figure 2, the result has shown that the percentage of the loss rate in the wired and Wi-Fi with policy is greater than the other models at the beginning when the offered load is less than 1 Gbps, but it will be less than the others when the offered loads are equal to or greater than 1 Gbps. When the offered load is less than 1 Gbps, the loss rate of the wired is less than the Wi-Fi; so, the loss rate of the whole system is high in the wired and Wi-Fi with policy because of the loss rate from the Wi-Fi. In contrast, the loss rate of the wired will increase rapidly when the offered loads are equal to or grater than 1 Gbps because it reaches to the maximum load of the line that can support. Due to splitting some offered load to the Wi-Fi, the loss rate of the overall system will decrease because the wired was not forced to support the entire load in the network.

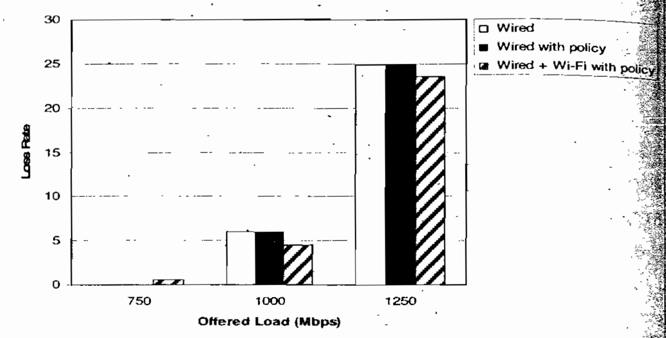

Figure 2. The average loss rate of the overall system in various network models when offered loads of the entire system are 750, 1000, and 1250 Mbps.

5.1.2. Department Throughput

Consider the percentage of loss rate that occurs in each department both of Inpatient building and Outpatient building in order to determine the difference between these 3 network models.

In the wired and Wi-Fi with policy, every department of Inpatient building has the percentage of the loss rate greater than the other 2 models at the offered load of 750 Mbps. At this point, the wired has a less number of loss rates compared to the Wi-Fi, so the loss rate of the wired and Wi-Fi with policy model is greater than the others. Additionally, the difference between applying with and without policy was not obviously shown in this experiment. In addition, it has the same loss rate in each department of Outpatient building as well.

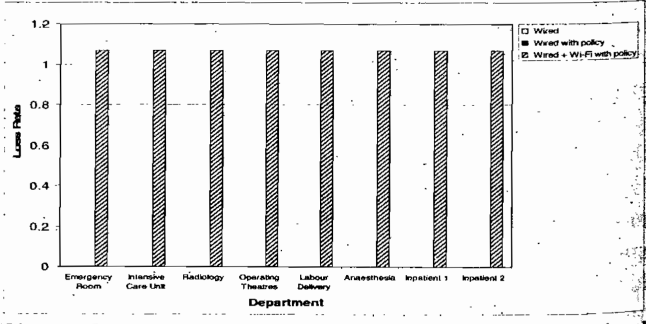

Figure 3. The average loss rate of each department in the Inpatient building when the offered load of the entire system is 750 Mbps.

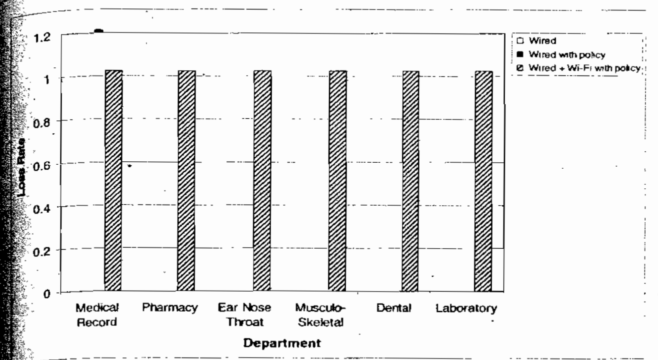

Figure 4. The average loss rate of each department in the Outpatient building when the offered load of the entire system is 750 Mbps.

When the offered load is 1 Gbps, the loss rate of each department is still low in the first 7 departments, but this value will increase rapidly in the last department, Inpatient 2 department, because the load reaches to the maximum value of the line in addition to First In First Out (FIFO) of queue type. In the first 7 departments in the Inpatient building, the loss rates of the wired are low and also closed to each other due to no policy in this model while the loss rates of the wired with policy will be the lowest (almost 0) in the highest priority departments, raise in the middle priority departments, and then reach to the highest one in the lowest priority departments. Also, the loss rates of wired and Wi-Fi with policy are in the same direction, but they are greater than the wired with policy due to the loss rate from the Wi-Fi. On the other hand, the loss rate of the wired and Wi-Fi with policy is less than the others in the last department due to splitting some part of the load to the Wi-Fi. Also, the result of the Outpatient building is in the same direction of the Inpatient building.

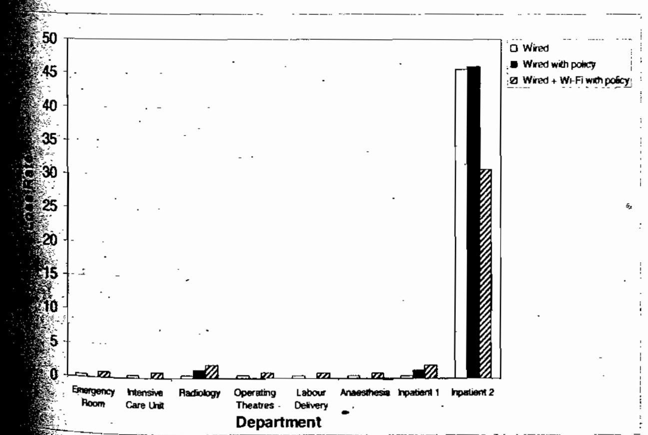

Figure 5. The average loss rate of each department in the Inpatient building when the offered load of the entire system is 1 Gbps.

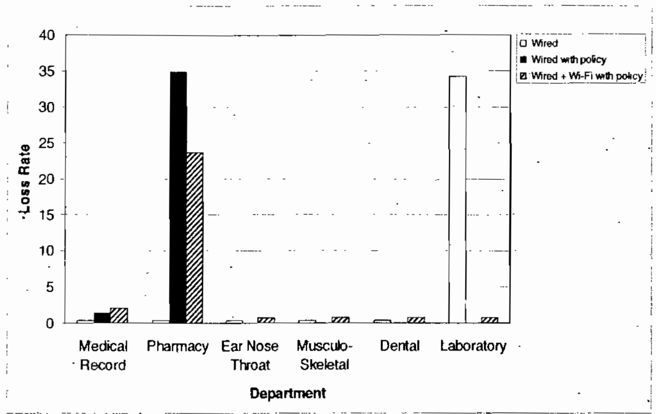

Figure 6. The average loss rate of each department in the Outpatient building when the offered load of the entire system is 1 Gbps.

When the offered load is 1.25 Gbps, the results are corresponding to the one with 1 Gbps load. According to the load is greater than the maximum of wired, throughput will be dropped rapidly in the last 2 departments in case of the wired model, and they are in the lowest priority departments in case of the other models. Therefore, the loss rates are very high in the Inpatient 1 and Inpatient 2 departments for the Inpatient building, the Dental department and the Laboratory department in case of the wired model for the Outpatient building, and the Medical record department and Pharmacy department in case of the wired with policy, and the wired and Wi-Fi with policy for the Outpatient building. Comparing these 3 models, the result has shown that the loss rates are the lowest in the wired and Wi-Fi with policy model for the departments, which have a great number of loss rates.

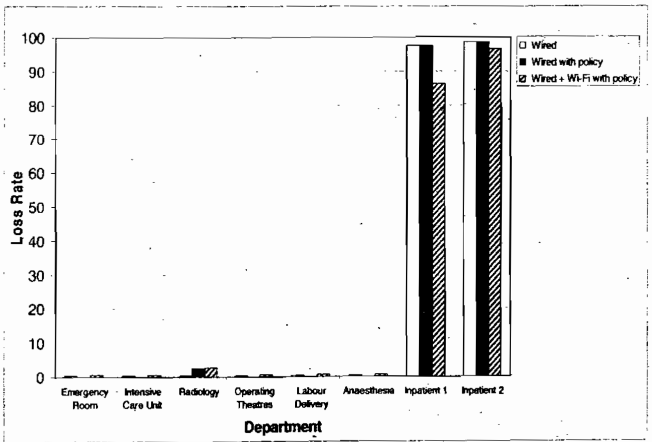

Figure 7. The average loss rate of each department in the Inpatient building when the offered load of the entire system is 1.25 Gbps.

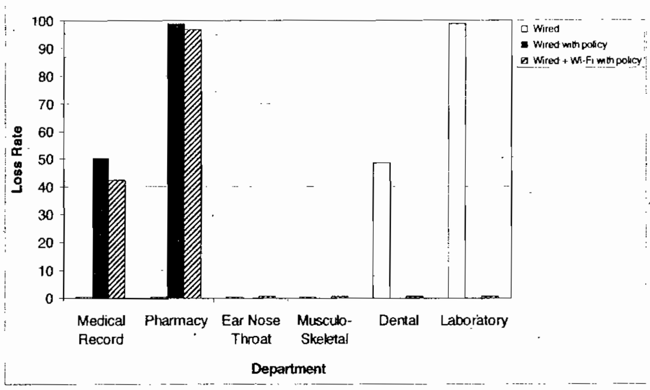

Figure 8. The average loss rate of each department in the Outpatient building when the offered load of the entire system is 1.25 Gbps.

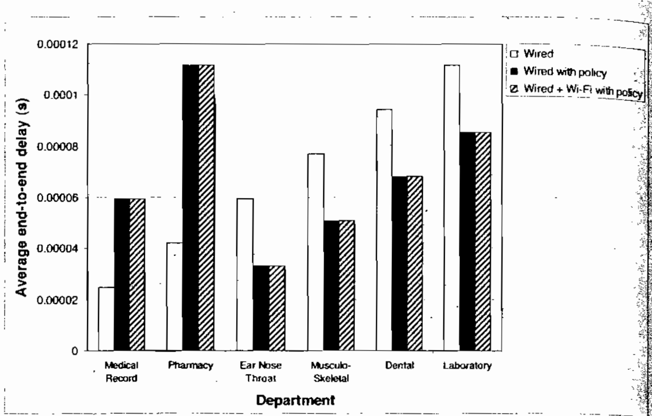

Figure 10. The average end-to-end delay of each department in the Outpatient building when the offered load of the entire system is 750 Mbps.

5.2. Delay

In this experiment, the different policies were implemented between the wired and wireless networks, so there are 2 main results: wired delay, and Wi-Fi delay.

5.2.1. Wired Delay

For the wired, the policy was setting up by considering the important in each department. Therefore, the average end-to-end delay in each department of the Inpatient building and the Outpatient building is considered in order to distinguish between applying the policy and without applying it.

When the offered load is 750 Mbps, the average end-to-end delay will increase continuously from the first to the last department because of First In First Out (FIFO) in Queue type. In case of applying the policy, the delay time is reduced in the highest priority departments, raised in the middle priority departments, and reached to the high value in the lowest priority departments. Furthermore, there are no difference between the wired with policy and the wired and Wi-Fi with policy at this point.

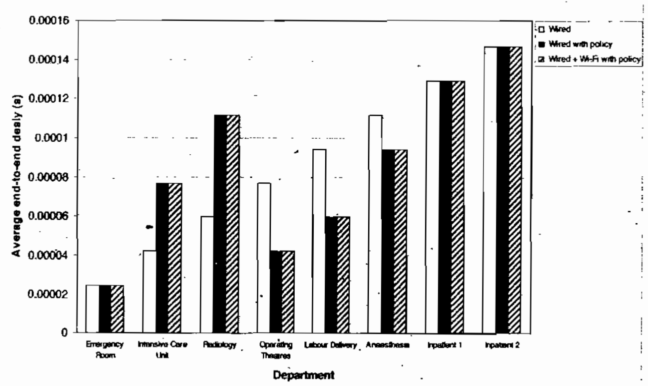

Figure 9. The average end-to-end delay of each department in the Inpatient building when the offered load of the entire system is 750 Mbps.

The difference between applying with the policy and without it can be noticeable at the offered load of 1 Gbps, and the delay also increased from the one at the load of 750 Mbps. In the wired, the delays are greater than the ones of the middle, and the highest priority departments in the other models, and are closed to each other due to no policy in this model. In the wired with policy, and the wired and Wi-Fi with policy, the results have shown that the delay are very low in the middle, or the highest priority departments while they increase rapidly in the lowest priority departments due to reserving the minimum delay for the higher priority departments. Additionally, the delay of the wired and Wi-Fi with policy are slightly decreased from the ones in the wired with policy model.

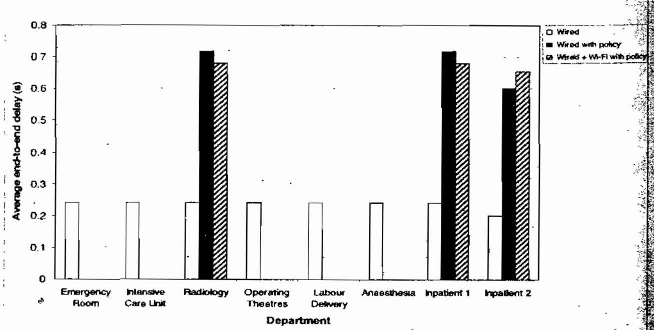

Figure 11. The average end-to-end delay of each department in the Inpatient building when the offered load of the entire system is 1 Gbps.

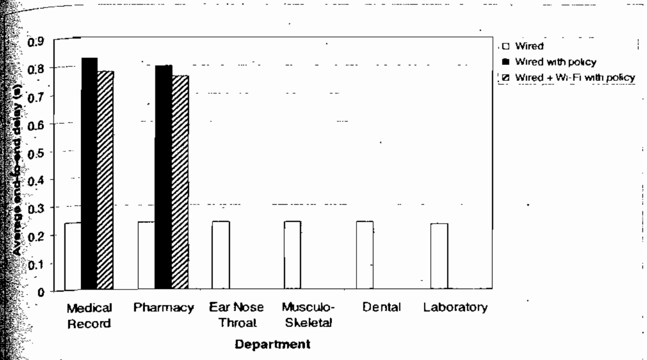

Figure 12. The average end-to-end delay of each department in the Outpatient building when the offered load of the entire system is 1 Gbps.

Furthermore, when the load is 1.25 Gbps, the results are consistent with the ones with 1 Gbps load, except that the values are higher. Even though, the load is greater than the maximum value of line that can support, the wired with policy, and the wired and Wi-Fi with policy models can efficiently reserve the minimum delay for the middle and the highest priority departments.

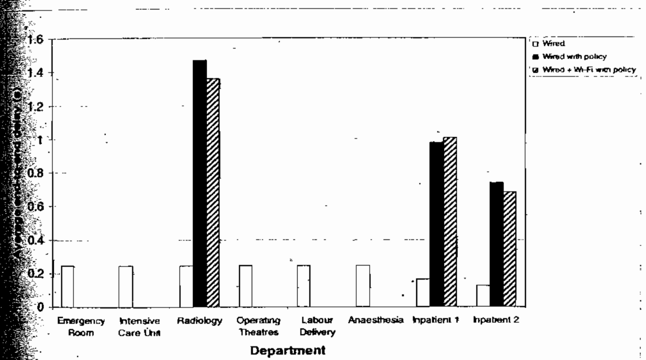

Figure 13. The average end-to-end delay of each department in the Inpatient building when the offered load of the entire system is 1.25 Gbps.

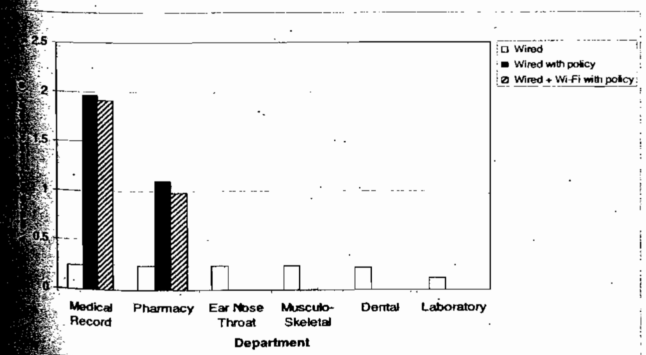

Figure 14. The average end-to-end delay of each department in the Outpatient building when the offered load of the entire system is 1.25 Gbps.

5.2.2. Wi-Fi Delay

For Wi-Fi, the policy was setting up by considering the objective and type of users. Then, the average end-to-end delay from the Wi-Fi will be considered to distinguish the difference between each flow type in the Inpatient building and the Outpatient building.

According to Figure 15 and 16, the results have shown that the flow of patient information, which is served for doctors and also involved in transmitting significant information, can achieve very low delay as well as the flow from doctors who would like to surf an Internet or access the e-service. Although the delay from the flow of Internet for patients has increased, the hospital can provide an Internet service to its patients while they are waiting for diagnosis.

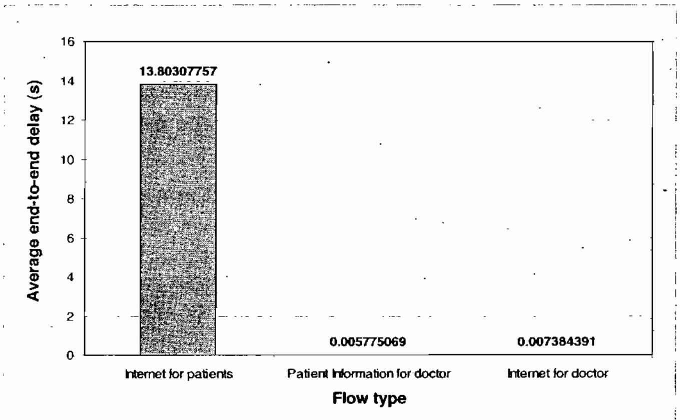

Figure 15. The average end-to-end delay of each flow type in the Inpatient building when the offered load in the Internet for patients, Patient Information for doctors, and Internet for doctors are 10 Mbps, 5 Mbps, and 5 Mbps, respectively

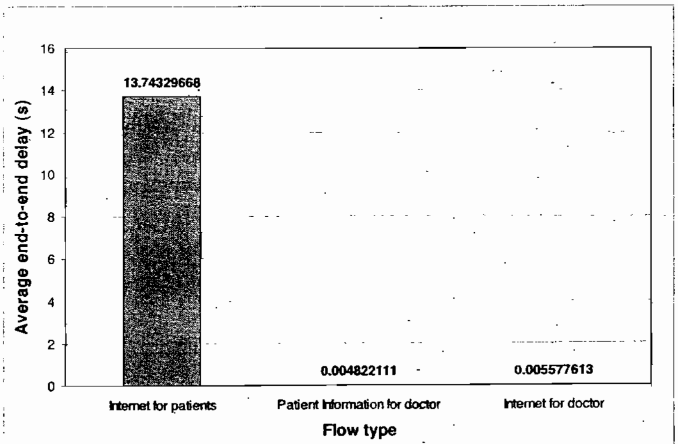

Figure 16. The average end-to-end delay of each flow type in the Outpatient building when the offered load in the Internet for patients, Patient Information for doctors, and Internet for doctors are 10 Mbps, 5 Mbps, and 5 Mbps, respectively

6. CONCLUSIONS

This paper proposes an alternative way to enhance a performance of a wired network by installing a wireless network to relief the traffic load, including setting up the policy in both of the wired and the wireless for reducing delay time. Additionally, the priorities for the significant departments and the flow types are prescribed for the wired and the Wi-Fi network. Comparing with these 3 models in the high traffic load, the results have shown that the model of the wired and Wi-Fi with policy can achieve the highest performance in reducing the loss rate while efficiently reserved the minimum loss rate and average end-to-end delay in both of the middle and the highest priority departments which involve in information significantly in vital. Additionally, installation of the wireless technology also supports portability and comfort for doctors and staffs within the hospital. Thus, they can use Wi-Fi devices from anywhere in the hospital to help them diagnose, update the significant information, or even, access the e-service while obtaining the minimum delay time.

7. REFERENCES

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