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HTTP AND FTP STATISTICS FOR WIRELESS AND WIRE-LINE NETWORK WITH AND WITHOUT LOAD BALANCE BASED ON OPNET

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Abstract This paper presents the modeling and implementation of Wireless Local Area Network (WLAN) based on OPNET. Here OPNET is used to develop a new model suitable for campus/university environment. Our model was then evaluated to measure the performance of the wireless local area network for such campus/university environment. We tested our model against two types of applications (ftp and http) in four sites and found that among a set of other parameters response time and wireless media access delay were highly affected by the number of users per application with and without load balancing. OPNET simulation showed the impact of loan balancing on wireless and wire-line network for two different types of applications.

Key Words, WLAN, Load balancing, Media Access Delay, Http response time, ftp response time.

1. Introduction

Wireless access points are now commonplace on many university campuses [1-4]. Technologies such as IEEE 802.11b wireless LANs (WLANs) have revolutionalized the way people think about networks, by offering users freedom from the constraints of physical wires. Mobile users are interested in exploiting the full functionality of the technology at their fingertips, as wireless networks bring closer the “anything, anytime, anywhere” promise of mobile networking. Wireless local area networks (WLANs) are spreading rapidly, their major advantage over wired ones being their easy installation. They offer many benefits to users who can access resources without being forced to stay in one place or indoors. The user base can be mobile, scalable, and create quickly-installed temporary networks. A typical campus/university mobile user (our study environment) has workstations equipped with a wireless card and the ability to access a local access point with minimal configuration required. The access point is linked to the wired network through a suitable IP gateway.

Several wireless 802.11 technologies are now available. IEEE 802.11b is the most well known technology. Its bit rate can be up to 11 Mbps in the 2.4 GHz band. The rate 11 Mbps is the theoretical rate. Due to overhead produced by ACK and synchronization issues, the rate does not exceed 7 Mbps [5-6]. IEEE 802.11g is an extension of 802.11b; and works in the same 2.4GHz band, its data rate can be up to 54 Mbps. IEEE 802.11a operates in the 5 GHz band up to 54 Mbps. IEEE 802.11a has the advantage of working in different band from cordless phones, microwave ovens, and Bluetooth. IEEE 802.11b and IEEE 802.11a are not compatible. For this paper we focus on IEEE 802.11b. More details on these technologies and

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others are available in reference [4].

Due to its limited bandwidth, wireless LAN performance is a hot research topic. The literature available showed that the performance of IEEE 802.11b based on wireless networks can be improved in different ways; such as tuning the physical layer related parameters, some IEEE 802.11 parameters, or using an enhanced link layer (media access control) protocol. Some researchers use the OPNET simulator to show that tuning the physical layer related parameters such as Slot Time, Short Inter-Frame Space (SIFS) and Minimum Contention Window can significantly improve the network performance. Also, by choosing appropriate WLAN parameters such as Fragmentation Threshold, WLAN performance could be improved in the face of high channel bit error rate (BER). They also indicated that the number of collisions can be reduced by the adaptive back-off algorithm in the MAC layer; this algorithm can also save power for wireless devices without affecting the performance of the WLAN. Other simulation results [2] show how the performance of IEEE 802.11b hosts can be influenced by the throughput of lowest host sharing the same channel; this could degrade the bit rate from 11 Mbps to 5.5, 2, or to 1 Mbps as a result of host movement or transmission problems. In practice, however, hosts which degrade their bit rate optimize packet loss by limiting their sending rate; a situation that might permit other hosts to benefit from the unused capacity.

Our paper uses simulation to study a campus/university area network scenario. We use the OPNET simulation environment, with its detailed models of IEEE 802.11b, TCP/IP, HTTP and FTP. OPNET was used because of it acceptance in the Performance Network Modeling Community and its track record of accurate representation of ‘real life’ communication protocols, and hardware element such as routers, switches, links and workstations.

Here the work reported in [7] has been extended. We parameterize the simulation model based on campus measurements, and validate the model against LAN performance metrics using simple HTTP and FTP workload models. We then build a model of browsing behaviour for a Web client and use this model in a simulation study addressing the performance of the campus area network. Our experiments focus on the HTTP and FTP transaction rate and end-to-end throughput achievable in the wireless network environment, and the impacts of factors such as page/object response time, wireless LAN media access delay, HTTP and FTP server utilization. Moreover the comparative investigation on various performance metrics in wireless and wire-line LAN for a balanced and unbalanced network has been presented.

After briefing the introduction in section I, Section II introduces our model, section III covers the scenarios we tested, section IV analyses the results and the conclusion is drawn in section V.

2 Model Outline

The IEEE 802.11 standard defines a set of wireless LAN protocols that deliver services similar to those found in wired Ethernet LAN environments. The IEEE 802.11 WLAN architecture is built around a Basic Service Set (BSS). A BSS is a set of stations that communicate with one another. When all the stations in the BSS can communicate directly with each other (without a connection to a wired network), the BSS is known as an *ad hoc* WLAN. When a BSS includes a wireless access point (AP) connected to a wired network, the BSS is called an *infrastructure* network. In this mode, all mobile stations in the WLAN communicate via the AP, providing access to stations on wired LANs and the world-wide

Internet.

We chose to use one of the sample models that come with the OPNET software making changes such as the hardware used, the interfaces allowed for each hardware, number and type of applications, number of users, types of links to reflect our model. Figure 1 & 2 shows an outline to the model and is followed by the four wireless LAN sites (Figure 3-6).

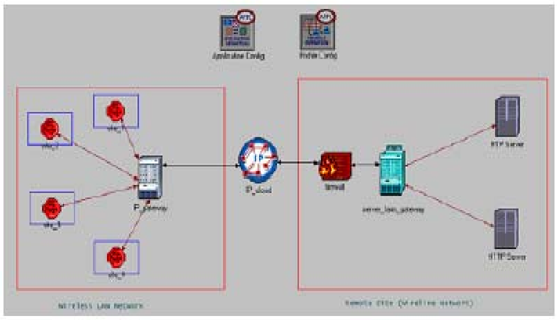

Fig. 1. OPNET Model without load balancer.

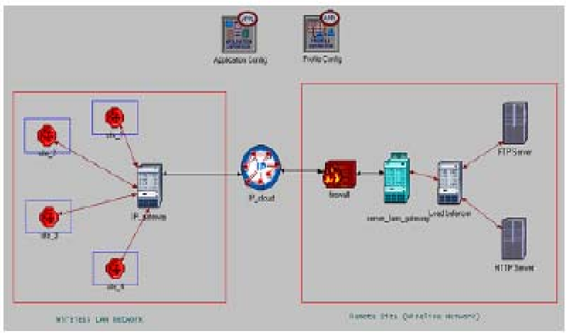

Fig. 2. OPNET Model with load balancer.

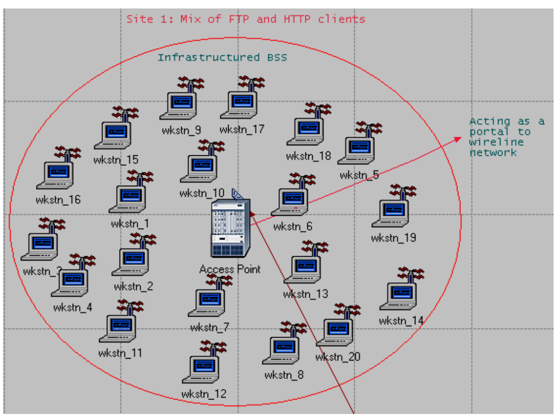

Fig. 1. Site 1: Mix of FTP and HTTP clients

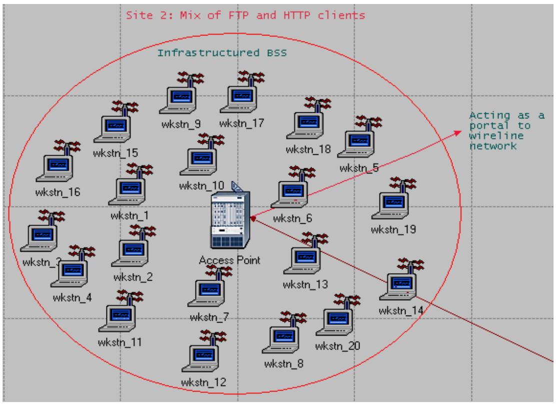

Fig. 2. Site 2: Mix of FTP and HTTP clients

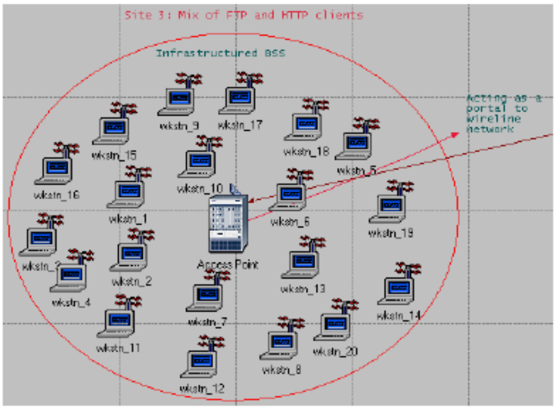

Fig. 3. Site 3: Mix of FTP and HTTP clients

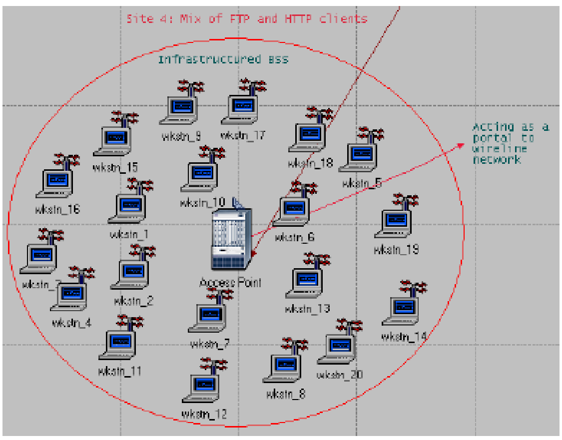

Fig. 4. Site 4: Mix of FTP and HTTP clients

In our research we considered installing four access points in a campus/university environment where mix of FTP and HTTP clients are there. Simulations have been carried out for our model to determine the optimal performance metrics. Table I and II indicate the application description and the wireless traffic generation parameters.

TABLE I. APPLICATION DESCRIPTION

Applications	Attribute	Load
Web Browsing	HTTP	Light
Homework Posting	FTP	Light

TABLE II. WIRELESS LAN TRAFFIC GENERATION PARAMETERS

Attribute	Value
Start Time Offset (seconds)	uniform (5,10)
Repeatability	Once at Start Time
Operation Mode	Serial (Random)
Start Time (seconds)	uniform (100,110)
Inter-repetition Time (seconds)	constant (300)
Number of Repetitions	constant (30)
Repetition Pattern	Serial

Efficiency Parameters

Table III summarizes the efficiency parameters we simulated. Notice that we didn't consider the packets; instead we used the bytes as a unit. Notice also that we have included some other global parameters to give us an overall picture about the average behavior of the model.

TABLE III. SIMULATED PARAMETERS

Application	Parameter	Unit
HTTP	Traffic Sent	Bytes/sec
	Traffic Received	Bytes/sec
	Response Time	Seconds
FTP	Download Response Time	Seconds
	Upload Response time	Seconds
	Traffic Sent	Bytes/sec
	Traffic Received	Bytes/sec
WLAN	Data Dropped	Bits/sec
	Delay	Seconds
	Load	Bits/sec
	Media Access Delay	Seconds
	Throughput	Bits/sec

3 Simulated Scenarios

A simulation model was developed using OPNET [6]. OPNET 802.11b PHY module was used as a standard with maximum data rate up to 11Mb/s. IEEE 802.11b frequency hopping was used in which $CW_{min} = 15$, $CW_{max} = 1023$ and slot time was 50µs. The packet size is 1024. In this section we will introduce the scenarios we tested; we have tested our model under these three scenarios. In each scenario we changed the number of users and the applications they are accessing:

Scenario 1: 4 WLAN Sites each with 20 users through 1 access points using FTP (10 users), and HTTP (10 users) connected with outside wire-line network without load balance (table I).

Scenario 2: 4 WLAN Sites each with 20 users through 1 access points using FTP (10 users), and HTTP (10 users) connected with outside wire-line network with load balance (table I).

Notice that scenario 2 is a duplicate of scenario 1 in terms of number of users and type of application each user accesses. More scenarios will be tested using the same model to discover the weak points of model in future work. In the following section we will show the resulted graphs' mapping between the two scenarios all at once and their analysis.

4 Results Analysis

Twelve graphs were selected after simulating our models (Figures 7 through 18). All graphs show a combination of the 2 scenarios. It has been investigated that the average FTP download response time with load balancer and without load balancer is 29.75 ms & 30.1ms respectively. Further, FTP upload response time with the load balancer is recorded between 29.3 ms to 30.1ms and while without the load balancer is between 29.2 ms to 29.5 ms. Here, we have kept the same settings & scenario for recording measurements for both FTP download and upload response time. Our investigations reveal that load balancer is useful in reducing the FTP download time, while in the process of balancing, in order to avoid the traffic congestion it rather takes more time. Thus, it is evident that the use of load balancer is not recommended for up linking processes.

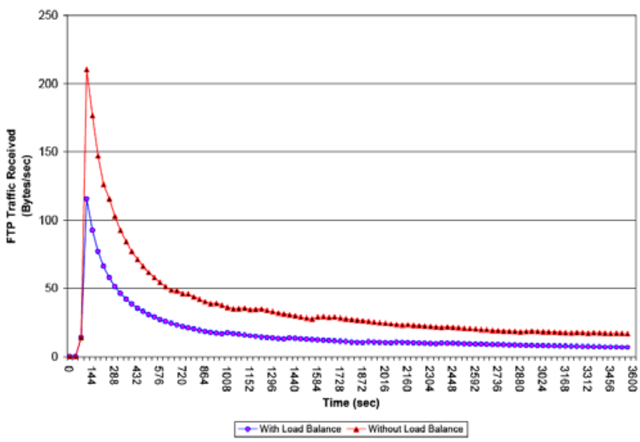

Fig 7 FTP Traffic received (bytes/sec)

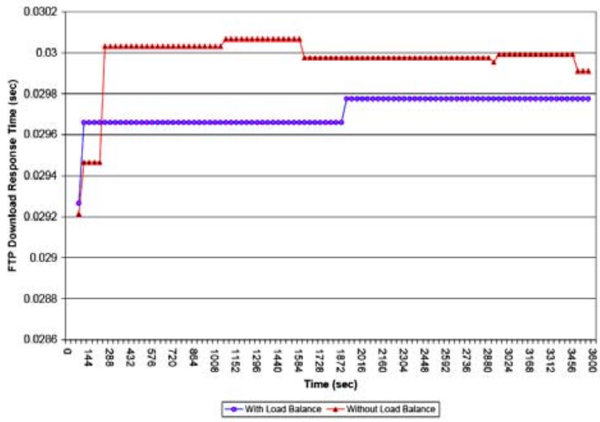

Fig. 8 FTP download Response time (sec)

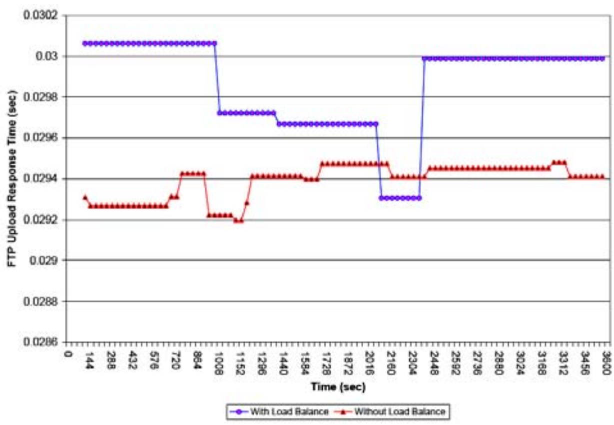

Fig. 9 FTP upload Response time (sec)

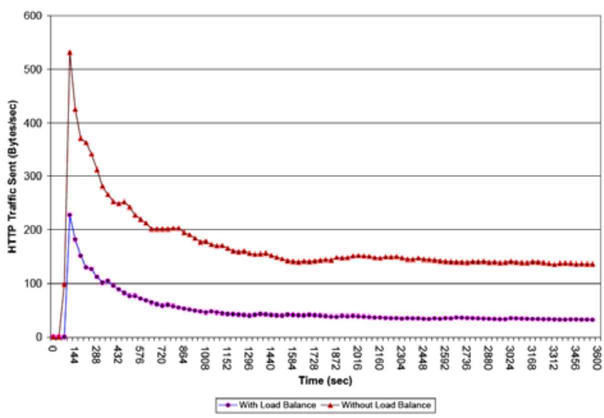

Fig. 10 HTTP traffic sent (bytes/sec)

A similar situation is noticed by the traffic received by the HTTP traffic response time, HTTP page response time and HTTP object response time. It can be deduced that there is a considerable difference between the HTTP page response time and HTTP object response time with respect to the load balancer and without load balancer. The HTTP page response time with the load balancer is found to be 34.5 ms initially and then reduces gradually to a constant value of 34 ms and without the load balancer it varies from 34.7 to 34.5 ms. In the process of locating the page, load balancer consumes more time in order to manage the traffic in comparison to the case where load balancer is not used. We observed that the average of HTTP object response time with the load balancer is found to be 13.75 to 14.2 ms and without load balancer is 13.59 to 13.71 ms. In case of HTTP object response time, the performance is better without load balancer, as it needs to manage traffic in order to locate the object.

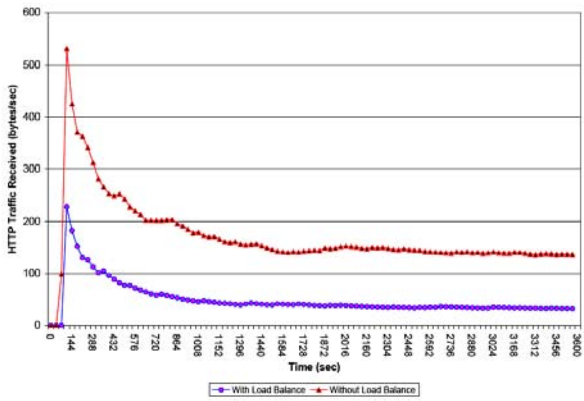

Fig. 51 HTTP traffic received (bytes/sec)

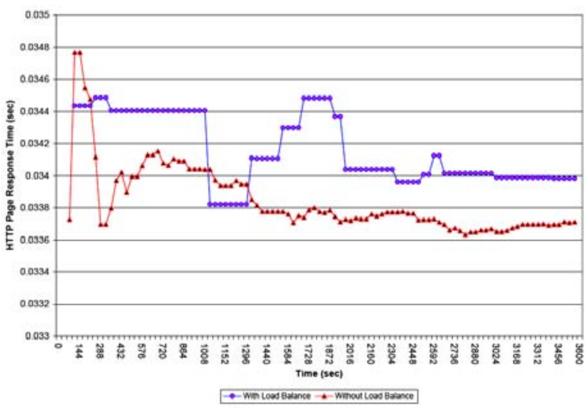

Fig. 62 HTTP page response time (sec)

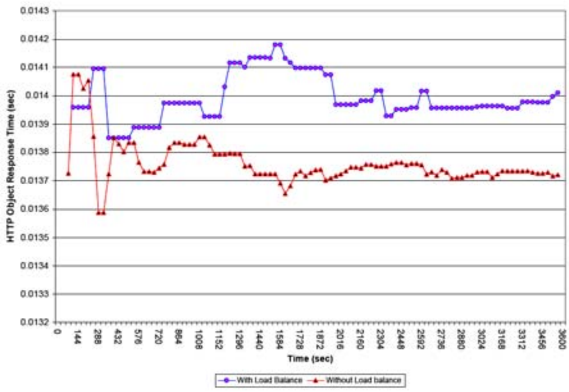

Fig. 73 HTTP object response time (sec)

As shown in figure 14 the wireless LAN delay in case of without load balancer is 1 ms while with load balancer it is 0.4 ms. Moreover it has been noticed that in both the cases the difference of wireless LAN and media access delay is of the order of 0.5 ms. Therefore it is concluded that the results are better with load balancer in comparison with without the load balancer. Further from figure 15 it has been pointed out that there is significant improvement in the wireless media access delay with load balancer which is 0.5 ms lower than without load balance.

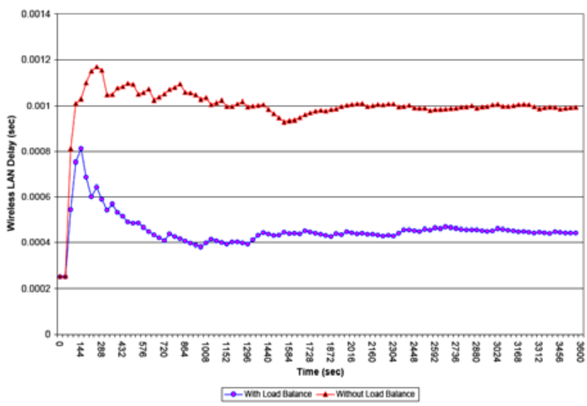

Fig. 84 Wireless LAN delay (sec)

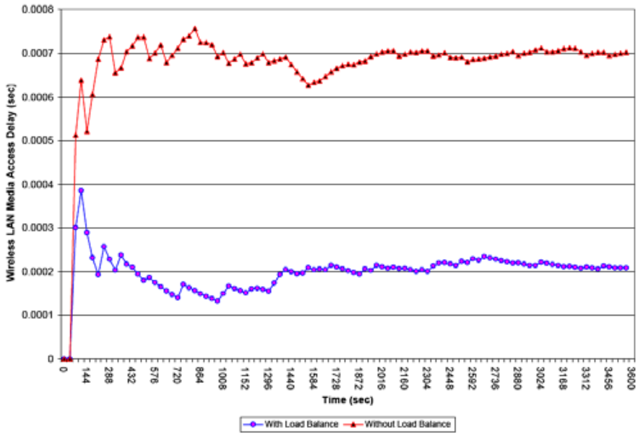

Fig. 95 Wireless LAN Media access delay (sec)

From figure 16 it has been observed that CPU utilization is 0.009% and 0.015% in case of FTP server with and without load balancer and it decreases exponentially to 0.0012% and 0.0018% respectively. Similarly the figure 17 indicates that the HTTP server CPU utilization with and without load balancer is 0.012% and 0.0255% and it decreases exponentially to 0.0019% and 0.0062% respectively. The results indicate that HTTP and FTP server utilization less in case of load balancing is in comparison with without load balancing.

Figure 18 show that there is marginal decrease in overall throughput of WLAN with load balancing and is of the order of 1 kb/sec because the load balancer need few seconds for balancing the input and output traffic on the network.

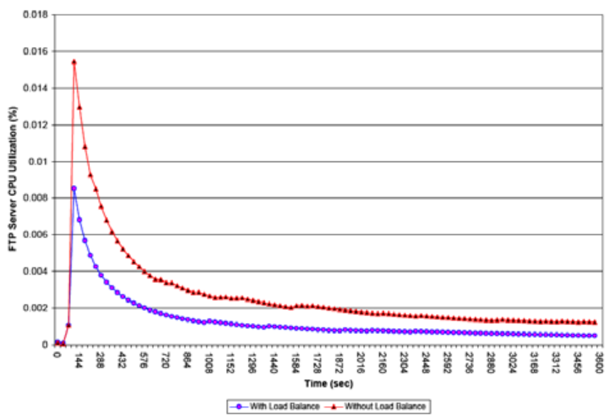

Fig. 106 FTP sever CPU utilization (%)

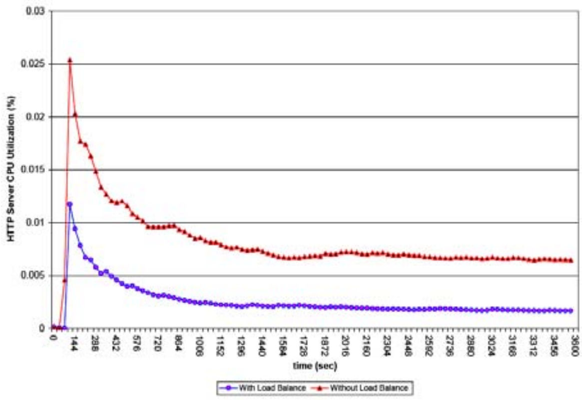

Fig. 117 HTTP sever CPU utilization (%)

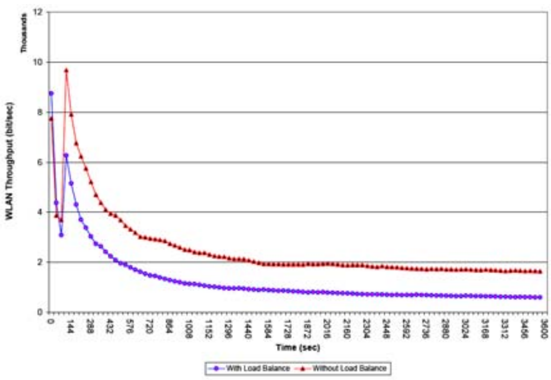

Fig. 128 WLAN throughput (bits/sec)

Conclusions

In this paper we have build a model of browsing behaviour for a Web client, and use this model in a simulation study addressing the performance of the campus area network. Based on OPNET we have focused on the HTTP and FTP statistics in the wireless network environment, and the impacts of factors such as page/object response time, wireless LAN media access delay, HTTP and FTP server utilization have been seen. Moreover the comparative investigation on various performance metrics in wireless and wire-line LAN for a balanced and unbalanced network has been presented. Our investigations reveal that load balancer is useful in reducing the FTP download time, while in the process of balancing, in order to avoid the traffic congestion it rather takes more time. Thus, it is evident that the use of load balancer is not recommended for up linking processes.

The observations indicate that HTTP traffic send and received is less in case of using load balancer while there is significant difference in comparison of without load balancing. The difference of 100 bytes/sec HTTP traffic has been observed with load balancing. The observed results indicate that there is marginal reduction in the HTTP page and object response time which is of the order of 0.2 and 0.3 ms without load balance. The results reveal that in case of HTTP object response time, the performance is better without load balancer because it needs to manage traffic in order to locate the object.

Further it has been noticed that the difference of wireless LAN and media access delay is of the order of 0.5 ms in both cases. Moreover the results indicate that HTTP and FTP server utilization less in case of load balancing. It has also been noticed that there is marginal decrease in overall throughput of WLAN with load balancing and is of the order of 1 kb/sec because the load balancer need few seconds for balancing the input and output traffic on the network.

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