H.263 Video Transmission in Wireless Local Area Networks using OPNET

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Abstract - *Digital video transmission in wireless environment comprises major challenge. Most of the video applications are delay sensitive and have relatively higher bandwidth requirements. Time-varying and asymmetric propagation proOerties of wireless links pose major challenge to low delay and ideally error-free transmission. Studies [1-4] suggest hybrid schemes, optimized control mechanisms or capability of WLANs to adapt to dynamic conditions of wireless link for video transmission. The variable nature of resources in a radio environment requires video clients also to adjust accordingly. Unlike studies [1-4], this work has been carried out to study the effect of mobility and mobility patterns on H.263 coding standard based video streaming in an IEEE802.11b WLAN. Numerous simulations, with different set of parametric settings, were performed using H.263 video traffic. Study results in verification of successful H.263 video traffic import in OPNET and some recommendations to make video clients in WLAN some what more intelligent by adapting to the variations in network resources due to mobility.*

Keywords: Mobility, video, H.263, wireless, simulation, Traffic

1. Introduction

The magnitude of the wireless communication industry is so huge that according to [2], as of the first week of June 2004, the mobile service industry broke the 1.5 billion subscriber mark worldwide. Research firm EMC also predicts that the industry will pass the 2 billion mark as early as 2006, far earlier than some other predictions, and reach 2.45 billion by the end of 2009 [2].

To get a glimpse of WLAN industry in specific, according to the Synergy research group's market analysis as presented in [3], the WLAN market is set to grow at an annual rate of 30% per year to nearly $5 billion by 2006. WLAN equipment sales have jumped 60% from this time last year to the present. WLANs for the home and small offices are projected to grow 103% and WLAN sales to the enterprise will grow at 32%.

1.1 Continuous Analysis and Improvements

As the technology evolves so do the applications. Some applications require better quality of service (QoS) than the rest. Wireless local area networks support numerous applications ranging from simplistic web browsing, email, file transfers etc. to delay sensitive voice and video applications such as voice over IP, video streaming, video conferencing etc.

In the last decade, the fields of multimedia communications and wireless communication networks have experienced unprecedented growth and commercial success. Video conferencing systems on general purpose computer networks have rapidly become a reality. The overwhelming interest in digital communication services drove the need for new collaboration tools which allow distant users to share real-time video, audio and data [1]. This trend is constantly evolving and therefore this advancement brings along the need for analyzing and improving the performance of wireless networks endlessly.

1.2 Importance of Simulation based Analysis

The complexity of modern communication systems is a driving force behind the wide spread use of simulation. This complexity results from both the architecture of modern communication systems and from the environments in which these systems are deployed. An important motivation for the use of the simulation is that simulation is a valuable tool for gaining insight into the system behaviour. A properly developed simulation is much like a laboratory implementation of a system. [5]

Simulation gives an ease to make any parametric changes and study the effects of that particular change on either a specific or overall performance of the system. A powerful and well developed simulation tool provides a lot of statistical information such as the bit-error rates, the signal to noise ratios, power spectral densities, packet loss ratio, delay times etc. which helps a lot to analyze a particular system with precision and accuracy. In [5], author explains that the essential components of a simulation framework for communication systems include a model builder, a model library, a simulation kernel, and a post processor. Individual packages differ in the way these components are implemented and in the scope and focus of the model libraries that are provided. A very well-reputed simulator, OPNET, has been used in this project. In addition to the state of the art simulation kernel and post processor, it provides wide range of model libraries (including the wireless local area network model library) to simulate different practical systems.

1.3 Scope of this Work

The main objective of the work was to (1) successfully import H.263 video traffic to OPNET (2) study the effects of mobility on H.263 coding standard based Video streaming under (i) different packet sizes under normal and abnormal traffic conditions (ii) different speeds with which the stations were moving in the network (iii) different receiver/transmitter power threshold levels. Therefore numerous simulations were performed with appropriate modeling of WLAN in respective cases. Several important results were obtained out of which some have been included in this paper and the recommendations have been summarized at the end.

Note: Results for (1) *and* 2 (i) *have been included in this paper.*

2. Mobility

Due to the wireless channel as a means of signal transmission, the wireless network transmission varies in time to quite an extent. Apart from the factors mentioned earlier, mobility of the network devices adds more complexity to the transmission process. Now, it is very important to note that mobility has different implication on the application layer. Different types of data (traffic) depending on the application undergo different levels of degradation in quality due to mobility. Changing position of WLAN terminals to another location with different channel conditions, and the speed with which the position is being altered; both factors affect the delay, throughput, bit error rate and ultimately the effective transmission rate. Http traffic is not normally delay sensitive, but on the other hand it requires lower bit error rates. On the other hand voice and video traffic can bear packet loss to some extent but higher delays can lead to poor quality of service (QoS) levels. Therefore the aim of this study is to analyze the effects of mobility and alteration in other parameters to reduce the delay as the video traffic is delay sensitive.

2.1 OPNET's Exquisite Feature: Mobility Support

The wireless module in OPNET provides extra ordinary features amongst which the most advantageous is the ability to simulate moving sites (terminals and/or sub-networks). This module also provides with the freedom to simulate not only one type of wireless system but systems such as the WLAN, satellite, UMTS etc. The mobility can be simulated by either using some pre-defined trajectories or user-defined trajectories. Station(s) or a network can be made to move according to defined trajectory and the performance of the networks can be analyzed respectively, which definitely provides with much more realistic results.

3. Need for Lower Bit Rates → Coding Techniques

Raw video requires a lot of storage space and it is not feasible to transmit this data especially over wireless networks. This is due to limitations of bandwidth which could be utilized efficiently by using coding scheme(s). As the applications grew so did the application specific coding techniques. The advances in low bit-rate video coding technology have led to the possibility of delivering video services to users through band-limited wireless networks [4]. The ITU-T video coding standards are denoted with H.26x (e.g., H.261, H.262, H.263 etc.) and the ISO/IEC standards are denoted with MPEG-x (e.g., MPEG-1, MPEG-2, MPEG-4, and MPEG-7).

- **H.263 → Standard for Video Conferencing & Telephony**

Amongst all these standards, H.263 video coding standard is of interest to us. This standard is video conferencing/telephony application specific, and has been developed after improvements to its predecessor H.261, which was finally approved in 1990. This standard, H.261, operated at 64 kbps or its multiples. Need for lower bit rate technique was always there due to limited bandwidth concerns. Therefore, in 1995 the H.263 standard was approved. This standard combines the features of H.261 and MPEG-1 and gives 30% bit rate saving as compared to MPEG-1. Further improvements such as, new negotiable modes, superior video quality, enhanced robustness, improved functionality of the target video coding systems, better coding efficiency, error resiliency for wireless video communications and support for interlaced video sources were achieved in newer versions, namely 2 and 3.

4. Basic Network Setup

A basic infrastructure mode network, comprising of one server, also serving as an access point, and nine mobile (and/or static) WLAN transceiver stations was initially designed and tested in order to verify error free functioning. The design process involved several steps, such as the (1) selection and setup of appropriate attributes of each device in the network (2) Proper traffic format, especially for the traffic which needs to be imported to OPNET project which needed time consuming conversion process from its format to OPNET compatible format (3) Appropriate packet sized traffic (each one converted separately) for some specific simulation scenarios (4) Application configuration setup for non H.263 traffic types in order to make simulation results more practical in the cases where needed (5) Mobility configuration setup in order to make the stations follow the developed trajectory with a certain speed. In order to give an idea as to what sort of network was designed, an illustration has been presented here, but parameters of different devices and traffic types were altered for specific simulation scenario/run as per the requirements of the study.

- **Attribute Setup**

The attributes of each device were modified according to the requirements. The most important parameters have been tabulated as follows:

Attribute	Setting
Data Rate	11Mbps
Physical Characteristic	Direct Sequence
Transmit Power	0.001W
Packet Reception-Power Threshold	7.33E-14
Buffer Size	256Kbytes
Max. Receive Lifetime	0..5s
BSS Identifier	Auto Assign
Roaming Capability	Disabled
Bandwidth	22MHz
Maximum Failed Polls	2
Beacon Interval	0.02s
Application Configuration Setting:	HTTP: Heavy Browsing FTP: High Load E-mail: Low Load Voice: Silence Suppressed IP Telephony
Operation Mode for Non video traffic	Simultaneous and Poisson at the start
Flow Mixing Mode	Full Mixing
Animation Update Frequency	1 simulation second
Server's Access Point Functionality	Enabled
Mobility Modeling Status	Enabled

Table 1: Important Parameters and their Setting for the Basic Simulation

5. Successful H.263 Video Traffic Import

The H.263 video file was downloaded from [6] and according to [6], target bit of the H.263 trace file used, Star War IV, was 16Kbits/sec. After converting this downloaded video file in to OPNET compatible video file it was then imported successfully to OPNET where it was then used to simulate H.263 video transmission in a WLAN. A profile of the imported video traffic can be seen from the figure below, it should be noted that this profile was created in OPNET based on imported traffic.

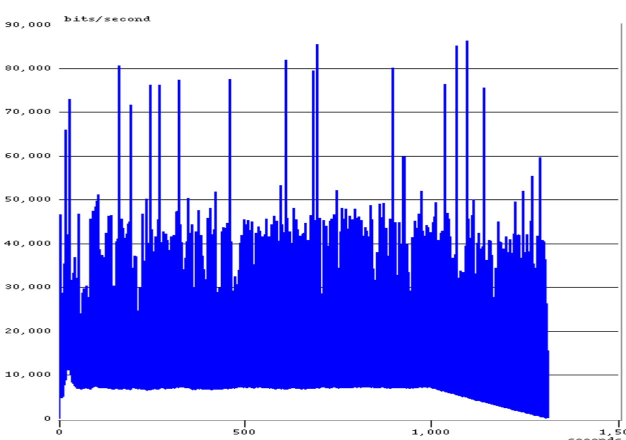

Figure 1: H.263 Traffic Profile of the imported video traffic

Some important properties of this video have been summarized in the table as follows:

Parameter	Value
Coding format	**QCIF (176x144pels)**
Frames to skip between each encoded frame	**0**
Reference frame rate	**25 frames/sec**
USE of PB-frames	**ON**

Table 2: H.263 Video Traffic Characteristics

6. Analysis and Discussion

The analysis was carried out through numerous simulations which have been presented in this section. Results have been grouped up into sub sections, each based on several simulation runs.

Study 1: Network comprising of H.263 Video Clients and non Video Applications based Stations – Effect of Mobility

- **Setup:**

The network was setup by using three H.263 video clients and the rest were configured for different applications such as the web browsing, file transferring etc. Two types of trajectories were developed. Trajectory used in the first scenario was developed in order to move the stations towards the access point and for the second scenario it was developed in order to move the WLAN station away from the access point. Stations using non video applications were solely used in order to get as realistic results as possible.

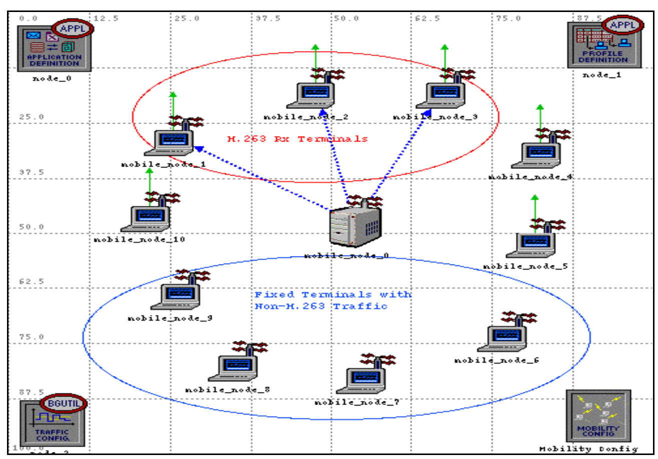

Figure 2: WLAN Setup

The blue dashed lines represent the imported traffic, which in this case was H.263 Video traffic. Where as the terminals without blue lines were configured to support four types of traffic, FTP, HTTP, Email and VoIP.

- **Main Objective:**

The sole purpose of these sets of simulations was to verify the proper system set up through visualization of the effect on network performance due to the mobility of stations with respect to the access point (the central controlling unit – through which all the stations in a network communicate).

- **Results:**

It was noticed that when the stations move away from the access point the performance degraded and the delay become larger. Similarly the media access delay (MAC delay) also increased as the stations moved away from the access point. On the other hand when the stations were simulated to move towards the access point, the performance improved as they moved closer and closer to the access point.

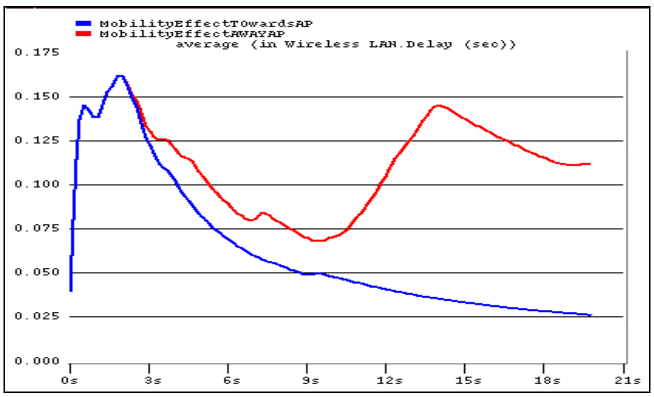

Figure 3: Average WLAN Delay with H.263 Video clients moving away (red) / towards (blue) the access point

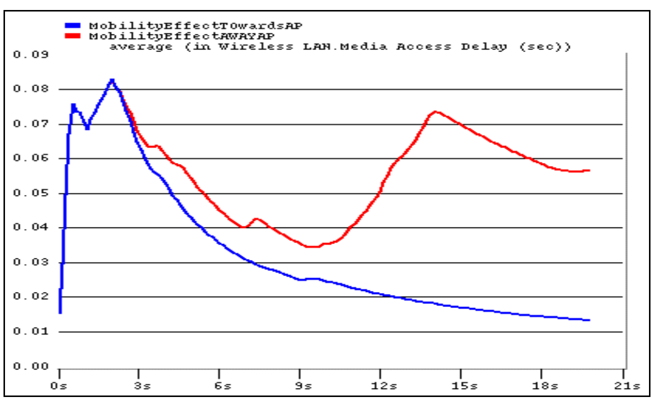

Figure 4: Average WLAN MAC Delay with H.263 Video clients moving away (red) / towards (blue) the access point

The plots (above) also show that the movement of the stations started after 10 seconds as the delay increase/decrease pattern changes with respect to the first 10 seconds.

Study 2: Comparison of 256 & 1024 (with and Without Mobility) under different load conditions

- **Setup:**

Two scenarios were created and simulated for this study. In the first scenario H.263 video traffic with packet size of 256 bytes was transmitted over the network and two runs of simulations were performed. During the first run, the H.263 clients were set to remain stationary where as in the second run of the simulation they were set to remain mobile based on the trajectory assigned. In the second scenario the similar set of simulations were performed but this time using the H.263 video traffic with packet size of 1024bytes.

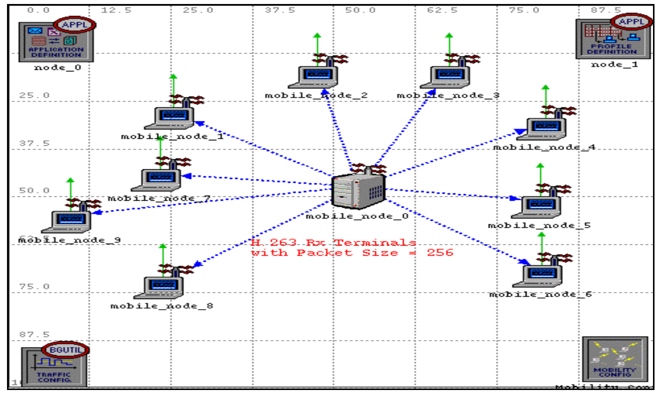

Figure 5: Networks Simulated with Video Packet Size of 256 and 1024 Bytes

- **Main Objective:**

The main purpose of this study was to see the effect of mobility on H.263 traffic with different packet sizes and find relation if there exits any.

- **Results:**

<u>Delay Performance:</u> The average delay of the overall WLAN increased due to mobility in both cases (H.263 Video traffic with packet size 256 and 1024 bytes), but when the results for 256 bytes packet size were compared 1024 bytes packet size there was no difference in the values and hence same plots were obtained.

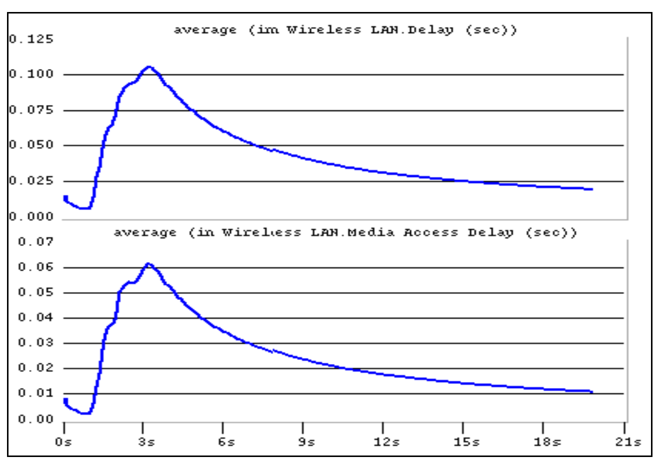

Figure 6: Average WLAN and MAC Delay with H.263 Video traffic (Packet size 256 Bytes) with Stationary Video Clients

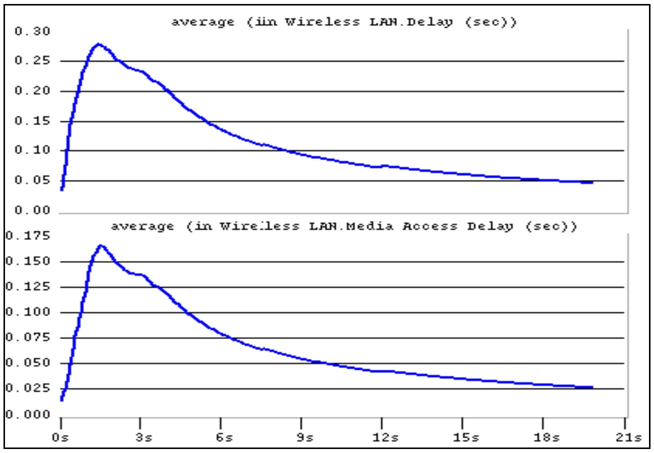

Figure 7: Average WLAN and MAC Delay with H.263 Video traffic (Packet size 256 Bytes) with Mobile Video Clients

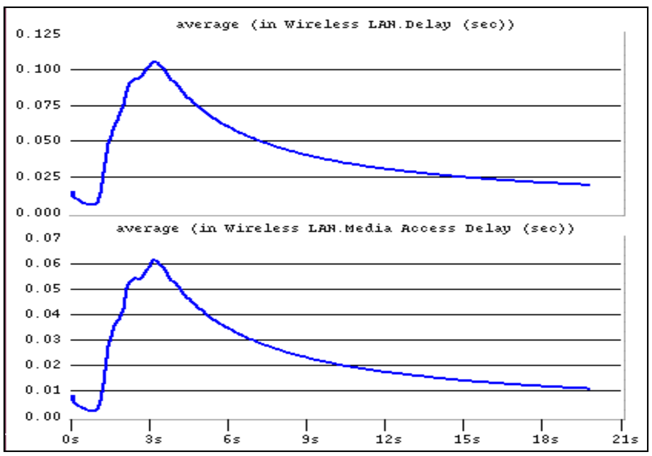

Figure 8: Average WLAN and MAC Delay with H.263 Video traffic (Packet size 1024 Bytes) with Stationary Video Clients

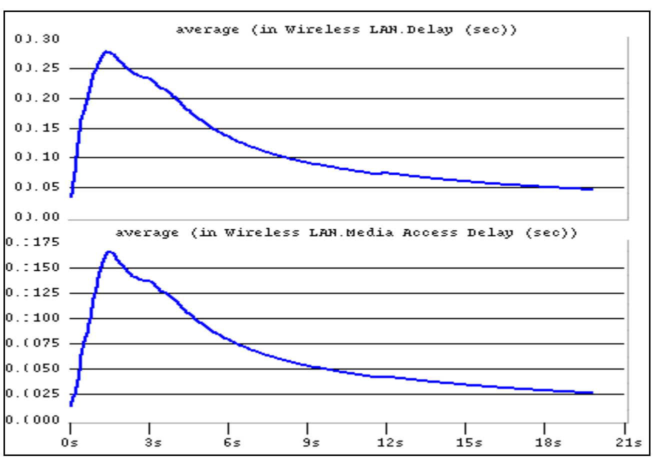

Figure 9: Average WLAN and MAC Delay with H.263 Video traffic (Packet size 1024 Bytes) with Mobile Video Clients

This was a little strange at first, but the reason became crystal clear when the simulations were performed under increased load conditions. It was not apparent until several simulations were performed and finally when the traffic was increased by a factor of 15, clear results provided decisive results.

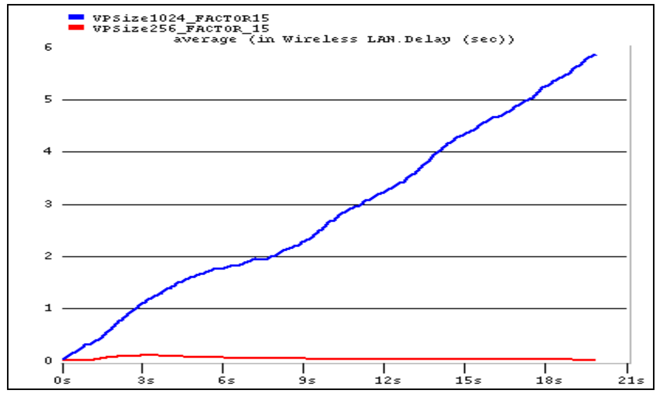

Figure 10: Average WLAN with H.263 Video traffic with Packet size(s) of 1024 (Blue) & 256 (Red) Bytes

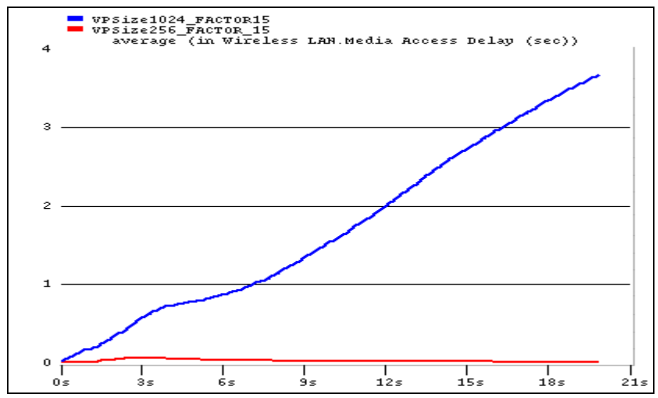

Figure 11: Average MAC Delay with H.263 Video traffic with Packet size(s) of 1024 (Blue) & 256 (Red) Bytes

This can be very well explained by the fact that as the traffic in the network exceeds, the larger packets, as they require more time for the transmission process to be completed, end up being dropped. The following plot of data dropped verifies this comment.

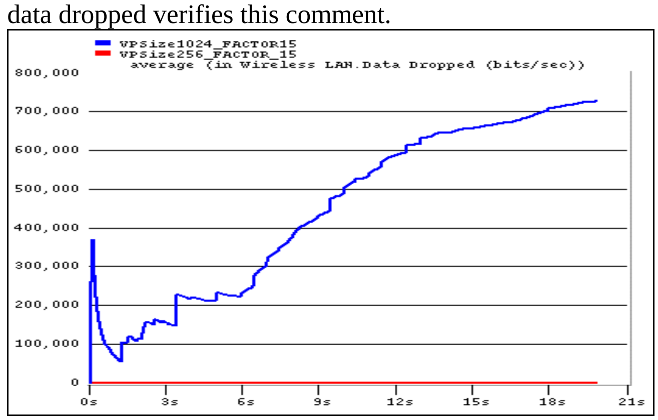

Figure 1: Average WLAN Data Dropped – Video Traffic with packet size(s) 1024 (Blue) & 256 (Red) Bytes

Load & Throughput Performance: The load and throughput performance followed the similar pattern as the delay performance. First the effect of the mobility upon the H.263

Video traffic was apparent (slight difference in the load and throughput performance) and following results were obtained.

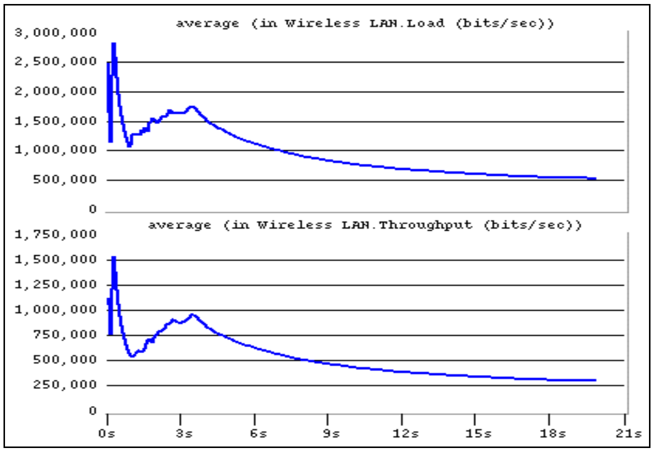

Figure 2: Average WLAN Load and Throughput with H.263 Video traffic (Packet size 256 Bytes) Stationary Clients

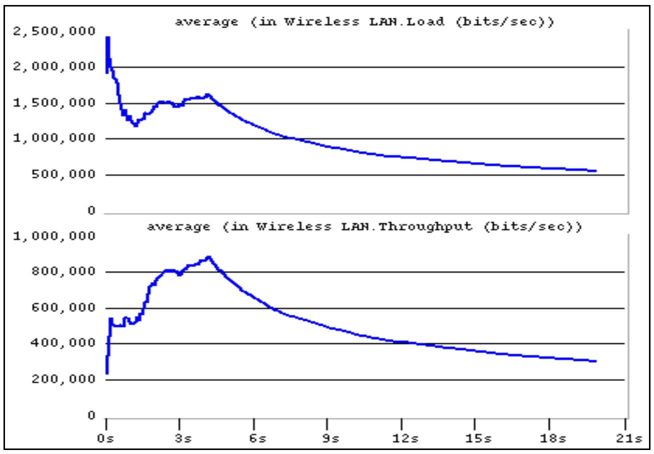

Figure 12: Average WLAN Load and Throughput with H.263 Video traffic (Packet size 256 Bytes) Mobile Clients

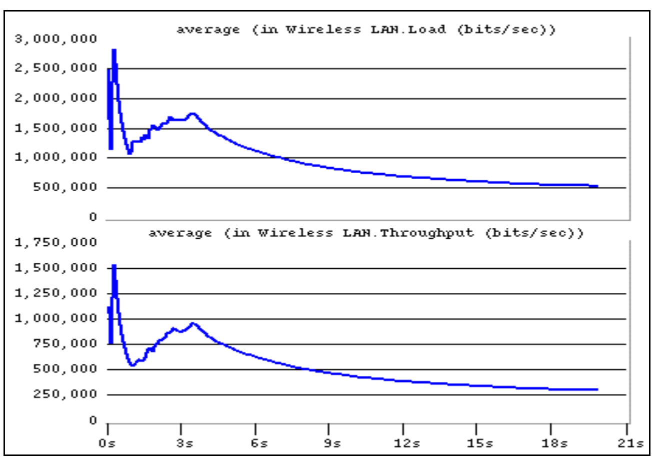

Figure 13: Average WLAN Load and Throughput with H.263 Video traffic (Packet size 1024 Bytes) Stationary Clients

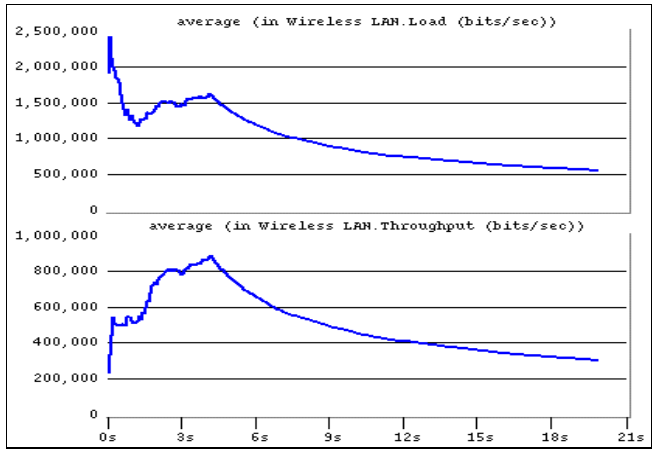

Figure 14: Average WLAN Load and Throughput with H.263 Video traffic (Packet size 1024 Bytes) Mobile Clients

Then later under mobile conditions, increasing the traffic by a factor of fifteen, the performance under traffic with two different packet sizes was studied as well.

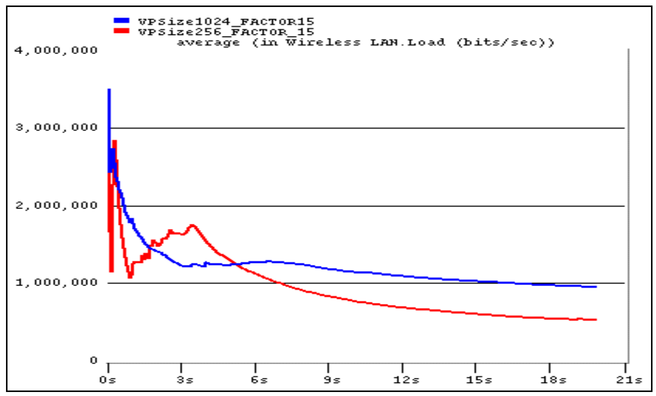

Figure 15: Average WLAN load when H.263 clients were mobile and Traffic increased by a factor of 15 as compared to the standard traffic used in the other simulations

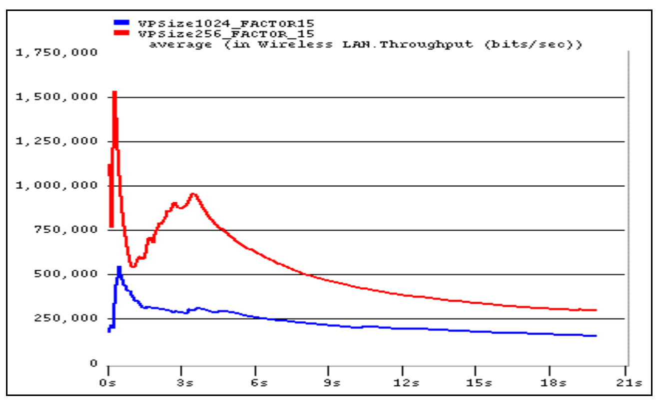

Figure 16: Average WLAN throughput when H.263 clients were mobile and Traffic increased by a factor of 15 as compared to the standard traffic used in the other simulations

As can be noticed from the figures above, the load on the network increased due to larger packet size whereas the throughput with larger packet size was much lower than the H.263 video traffic with packet size of 1024 bytes.

Hence, the performance of H.263 video transmission, in a heavily loaded network, is better with the lower packet size, i.e. 256 bytes of packet size outperforms the performance of network with H.263 video packet size of 1024 bytes.

7. Conclusions and Future Work

Real-time video services require high reliability with a low bounded time delay and a reasonably high transmission rate. Wireless channels, on the other hand, are error prone, time varying, and band limited [4]. This study was aimed at analyzing the wireless local area network's performance (with streaming H.263 standard based video) under mobility. Although some of the results turned out to be as expected, but nevertheless they provided with a very good understanding of the issues and limitations in a practical network. The effect of mobility due to stations being mobile was very much apparent. The direction and/or pattern in which a station moves also had a great impact on the improvement or degradation in the performance. In some of the cases understudy the performance of H.263 clients turned out to be different then the overall network performance, this was perhaps due to the nature of the H.263 Video traffic itself and other factors such as the other applications (Http, Ftp, E-mail & VoIP) running in a network simultaneously. Performance variations due to difference in the packet size used (256, 512 & 1024 bytes), although same H.263 video being transmitted from the H.263 server to the clients at target rate of 16kbps.

Part of the study will be published in future which will provide an insight to the way in which the receiver power threshold modifications impacted the overall performance of the network as it provided with an idea which could be further worked upon by making H.263 clients more intelligent. Based on this it can easily be concluded that in future the H.263 video clients can be made more aware of the network conditions in general and mobility information in specific with which the video clients (WLAN stations) could control the receiver power threshold levels based on the speed and pattern of their motion (whether away or towards the access point/H.263 Video server). This would allow them to adapt to the environment intelligently and enhanced QoS (quality of service) levels would be achievable under dynamic conditions. Delays could easily be lowered by using these cross-optimizations for network conditions different than normal.

Based on this study the performance of wireless networks during streaming video transmissions can be enhanced by the availability of video files at the server with more than one packet sizes which would be selected either by client or server depending on the network dynamics. Further research can be done by using H.264 standard based video traffic instead of H.263 and it can then be compared with the study performed here (H.263 standard based video) which could definitely result in more conclusive results. The effects of mobility & interference due to roaming could also be studied using the network model already designed during this study which already has the H.263 video traffic (which was imported after some processing). Based on the same system (designed during this study), effects of mobility and other parameters could be studied in an H.263 based video broadcasting WLAN.

In short, this study provides the model which forms could form the basis for numerous related projects/studies/research which could lead to more robust and intelligent futuristic Video streaming wireless local area networks functioning in dynamic environments with even different systems running in parallel.

8. References

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