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Effects of Lline Rate on vVideo QoS over Wireless Networks: an Experimental Approach

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Effects of Line Rate on Video QoS over Wireless Networks – an experimental approach

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Abstract

Video Streaming over Wireless Local Area Networks (WLANs) is becoming an increasingly popular service. However, end user QoS is highly influenced by many factors. These include the video codec used, the packetization scheme, error concealment and correction techniques, the complexity of the video, propagation losses, and the line rate. In this paper the effect of the line rate on the capacity of the network when streaming multimedia content is analyzed experimentally. It is shown that as the line rate decreases the bandwidth load of the video stream dramatically increases leading to poor QoS at the client side. As automatic line rate adaptation schemes are typically employed in the majority of WLAN adapters, clients have no control over the line rate of their connection and consequently can suffer from a poor QoS for their video streaming services.

Keywords: Video Streaming, WLAN, Multimedia, Quality of Service

1 Introduction

In recent years there has been a significant increase in the availability of Wireless Local Area Networks (WLANs) both in the home and in business. Similarly, there has been an increase in public access "Wi-Fi Hotspots" in restaurants, hotels, cafes, airports, etc. Some are provided free of charge as a courtesy service to customers while others are only available through a subscription service.

As more and more people have access to a high speed network there has also been an increase in the popularity of multimedia streaming [1]. Problems can arise here as multimedia streaming and rich media place an onerous bandwidth requirement on bandwidth limited wireless networks. The wireless medium also suffers from high loss rates due to propagation errors, fading and cross-talk, further compounding the problem.

Transmission errors can be mitigated against for FTP and TCP traffic by using the retry mechanism. However, the UDP protocol used for video streaming does not allow retransmissions because as a time critical service the retransmitted data could arrive after the play out time where it will be dropped by the video player as it is unnecessary. Some steps have already been taken to prioritize video traffic over background traffic. The IEEE 802.11e standard employs a Enhanced Distributed Channel Access (EDCA) mechanism to partition data on the network into four service categories known as *Classes of Service* (CoS) namely Voice, Video, Best Effort and Background. By tuning the values for the *Contention Window* (CWmin) and *Arbitration Inter Frame Space Number* (AIFSN) parameters one can prioritize the access that a CoS has to the wireless medium.

Many wireless gateways and routers also make decisions on which line rate to use, i.e. if the wireless signal drops below a certain threshold the line rate can be lowered to reduce the retry rate. This can be affected by propagation distance or obstacles between the wireless transmitter and receiver. However, as the line rate is lowered the bandwidth utilization dramatically increases. The IEEE 802.11e EDCA mechanism may still help to prioritize the video traffic, but it cannot provide the additional capacity required. In this paper we experimentally investigate the effect that the line rate has on the network capacity and how this impacts the video stream [2].

The remainder of this paper is structured as follows. In section 2 of this paper the preparation of the video content is discussed. This is followed in section 2.1 where the details of the experimental testbed are introduced. The experimental procedure is detailed in section 2.2 and the results are presented in section 2.3. Finally, some conclusions and areas of future work are discussed in section 3.

2 Experimental Preparation

For these experiments, 5 different video contents were encoded into MPEG-4 simple profile files using the Dicas X4Live MPEG-4 [3] encoder. The generated files are 600 seconds in duration with an I-frame occurring every ten frames and a bit rate of 1000kbps. The video has an overall frame rate of 25 frames per second (fps). Different MTU values were also generated using the MP4Creator software that is packaged with the MPEG4IP [4] bundle. This was accomplished by generating a hint track for the video stream found in the MPEG-4 file. The hint track is then used by the streaming server software to determine how the video content should be packetized.

A total of 5 different video clips were used, each with 2 different MTU values. The clips were labeled *DH*, *DS*, *EL*, *FM* and *JR*. These clips were chosen as they all exhibit varying video complexity characteristics. The video clip labeled *DH* is taken from the action film “Die Hard”, scene changes occur frequently and the clip contains several bright explosions. *DS* is taken from the film “Don’t Say A Word”, the pace of this clip is slower with fewer scene changes. *EL* is taken from the animated film “The Road to Eldorado”, which has hard and defined edges and bright colours. *FM* is taken from the Film “Family Man”, this particular clip is quite dark and slow moving with a high level of shadow detail. *JR* is an extract from the film “Jurassic Park”, a fast moving, bright action film with very complicated textures. This selection of films should present a large variation in content complexities to the video encoder [5].

2.1 Experimental Test Bed

The experimental test bed is shown below in Figure 1. To facilitate the streaming of the video files a video server running Darwin Streaming Server [6] from Apple was set up on the wired side of the network. This allows for the streaming of Quicktime, MPEG4 and 3GPP files using RTP and RTSP protocols. Also on the wired side of the network was a PC running the CNRI Wireless Radio Resource Controller (WRRC) [7]. This software monitors the wireless network traffic using the Cace Technologies AirPcap [8] 802.11 Wireless Packet Capture device. The information gathered by this application was used to produce the results below. The Wireless Access Point is a Cisco Aironet 1200 AP and the wireless clients utilize the Netgear WAG 511 Wireless PC Card to communicate with the AP. Quicktime software from Apple is used to view videos at the client side.

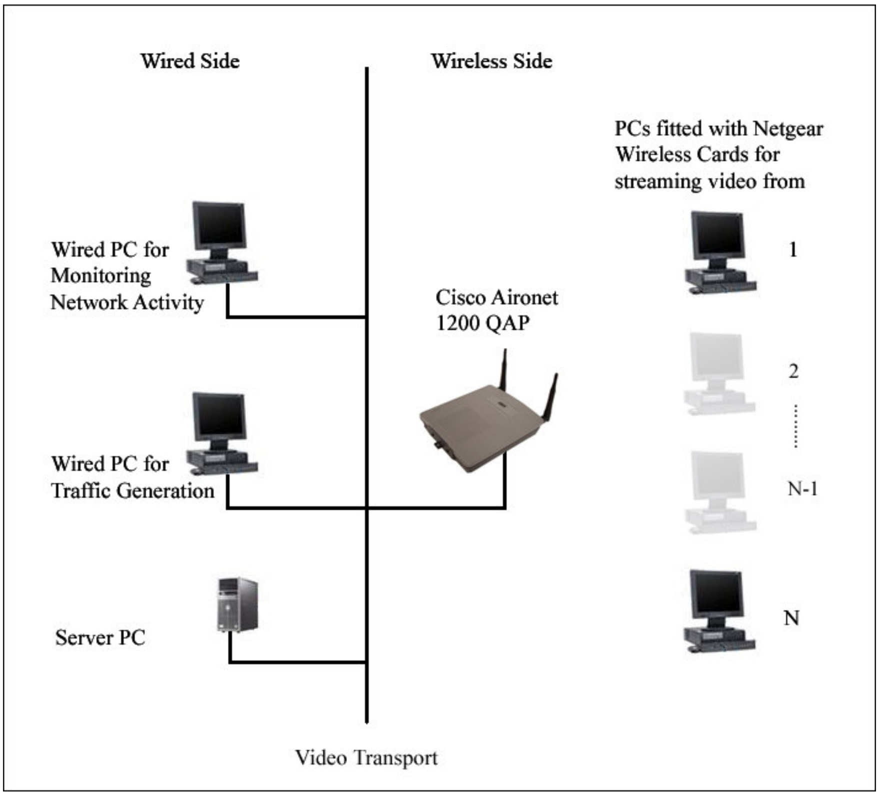

Figure 1: Experimental Test Bed used for Video Streaming on WLAN

2.2 Experimental Procedure

Each video was streamed from the server to the client with MTU settings of 512 bytes and 1000 bytes and with a line rate of 11Mbps. This transmission was monitored using the Windump [9] software, this generates a log file of the transmission containing packet transmission time, protocol used, data type, sequence number and marker bit information. This log file was then utilized to generate an input file for the RTPDump [10] software allowing the complete remodeling of the video transmission. RTPDump could then be used to model all aspects of the video transmission, it also allowed for a log file to be generated at the client side with the RTPRecv software. This is advantageous as it allows for log file to log file comparison of the input and output files instead of the more cumbersome video file to video file comparison.

Beginning with the line rate set to 1Mbps, RTPDump was used to simulate the video transmission from host to client. A standard telnet session was used to increase the line rate at the AP every 150 seconds through the standardized 802.11b line rates of 1 Mbps, 2 Mbps, 5.5 Mbps, and 11 Mbps.

The CNRI WRRC was used to monitor and record the transmission allowing for analysis of the bandwidth performance.

2.3 Results

The results of the experiments can be seen in Figure 2 and Figure 3. Figure 2 displays how the bandwidth load varies for the video clip labeled *DH* when it was transmitted using a MTU value of 1000 bytes. The line rate is initially set to 11Mbps and changes to 5.5Mbps, 2Mbps and 1Mbps at 110 seconds, 265 seconds and 415 seconds respectively. It can be clearly seen here that the bandwidth load increases dramatically as the line rate is lowered. All the other video clips exhibited a similar result.

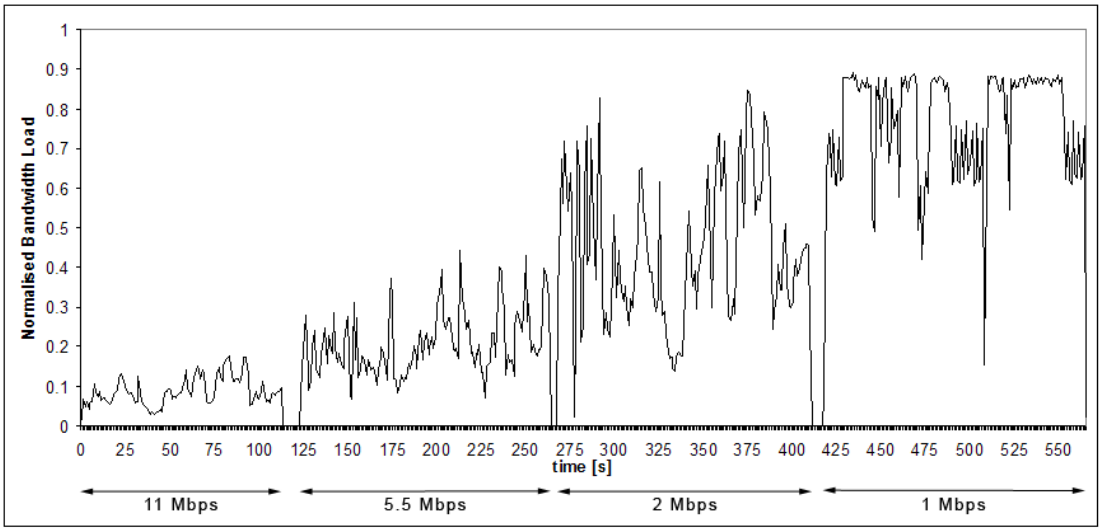

Figure 2: Bandwidth Load vs. Time for Video Clip Labeled *DH*, MTU = 1000 Bytes.

The graph in Figure 3 shows the average capacity required for each video stream measured over a 150 second interval versus the line rate used for different video clips and packetization schemes. This graph clearly shows how the capacity is also affected by the packetization scheme employed. As can be seen here, a decrease in the line rate can severely limit the number of video streams that the WLAN medium can support. At 11 Mbps and depending on the MTU parameters used, one can observe that between 5 and 10 video streams can be accommodated. At 1 Mbps, the number of streams that can be accommodated has dropped to one. It was also noted during the experimental process that at 1 Mbps that frame stuttering and blocking were more apparent compared to when the line rate was set to 11 Mbps. It could be therefore argued that at 1 Mbps the wireless medium has difficulty accommodating even a single video stream satisfactorily.

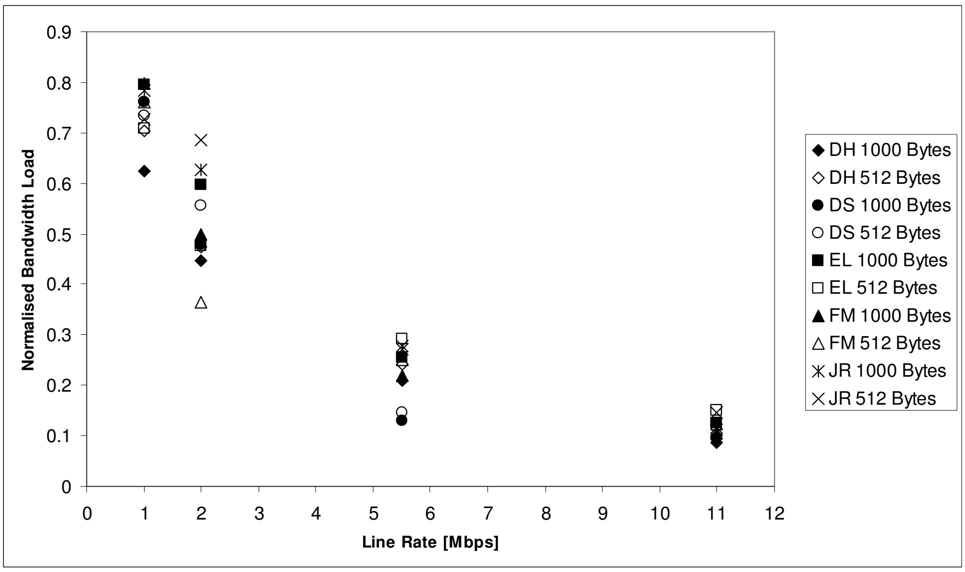

Figure 3: Average capacity for all video clips vs. line rate

	Line Rate [Mbps]			
Clip	**1**	**2**	**5.5**	**11**
DH	512	512	512	512
DS	1000	1000	512	512
EL	1000	1000	512	512
FM	1000	512	512	512
JR	1000	512	512	512

Table 1: MTU Value Requiring More Bandwidth for Each Line Rate and Video Clip

Table 1 shows which MTU value for each video clip required more bandwidth based on the graph in Figure 3. It can be seen that the video clip *DH* with an MTU value of 512 bytes required more bandwidth than a MTU of 1000 bytes for each of line rates defined in the standard. The video clips labeled *DS* and *EL* require more bandwidth when packets of 1000 bytes are being used at both 1Mbps and 2Mbps. However, for line rates of 5.5Mbps and 11Mbps a MTU of 512 bytes requires more bandwidth. Similarly, for the video clips labeled *FM* and *JR* there is a change in the MTU size when the line rate switches between 1Mbps and 2Mbps. It can be seen from this table that in order to minimize the bandwidth required by a video stream it is necessary to dynamically tune the packetization scheme depending on the video complexity and the line rate being employed.

Conclusions

Video streaming applications are bandwidth intensive services which can be affected by many factors at the video, codec, and server level. When streaming video over a bandwidth limited wireless medium further limitations are encountered due to transmission errors and fading.

To combat the hostile transmission environment, many vendors employ an automatic line rate adaptation technique on their wireless equipment. This approach reduces the transmission data rate as the packet loss rate increases and the client is usually unaware of any changes to the line rate. The IEEE 802.11b WLAN standard provides for four lines rates, i.e. 1Mbps, 2Mbps, 5.5Mbps, and 11Mbps. However, as a consequence the bandwidth required by a data stream can varying by a factor of 11 as the line rate switches between 1Mbps and 11Mbps.

In this paper the effects of line rate on network capacity for video streaming applications has been experimentally investigated. It is shown that as the line rate is lowered the network capacity required for the streaming application increases dramatically. The IEEE 802.11e QoS standard can still be employed to prioritize the video traffic over other traffic types, but it cannot provide any additional capacity. A better approach to increase the video QoS would be to employ a codec that could alter the encoding parameters based on the network conditions or to employ a server that could change the video packetization scheme based on the network conditions.

The IEEE standards body is still working on the new 801.11n standard and the second draft has been approved. In the wake of this some vendors have released 802.11n draft compliant devices. The new standard aims to increase the data rate to 300Mbps utilizing Multiple-Input Multiple-Output technology.

This technology may make the challenge of streaming High Definition (HD) video content over wireless networks easier to overcome due to the higher data rates used. Currently, there are a number of commercially available products on the market that stream HD over 802.11a/g networks using integrated systems [11].

Further work is required to quantify the advantages that the IEEE 802.11e QoS mechanism will provide through dynamic EDCA parameter tuning. Also, an investigation into how video QoS is affected by propagation distance with the line rate adaptation mechanism disabled is planned.

Acknowledgements

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