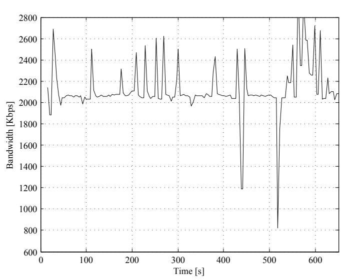
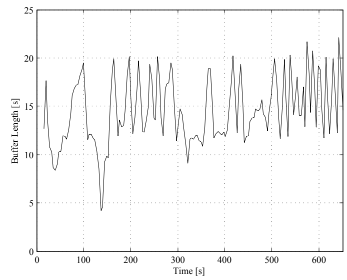
seconds). The dropped frames rate forces the video quality to switch lower bitrates as noticed at 99, 368, and 500 seconds. The video quality also changes due to available bandwidth as it is observable at 300 seconds.



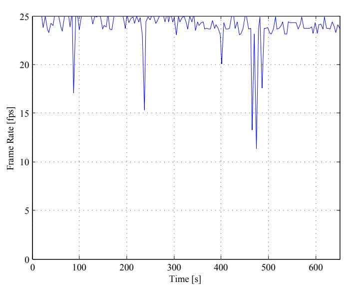
(a) Bandwidth



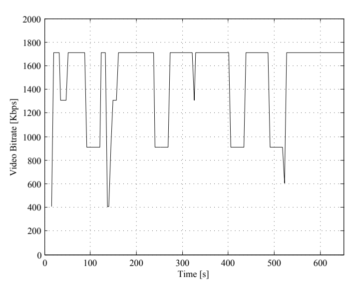
(b) Buffer

Figure 3: Client Bandwidth and Buffer in WLAN

The proposed algorithm is also evaluated in WLAN network, and mostly its maximum available bandwidth is more than 2 Mbps as shown in Figure 3a. The result shows that there are two times when large decrease in bandwidth are observed that result the switching of video quality to the next lowest possible quality, as illustrates in Figure 4b. The graph in Figure 3b depicts that client's buffer continuously fluctuates, and mostly it has value above than the preferable buffer length. The proposed method tries to keep the buffer length above than the preferable buffer length in order to avoid the stalling in playback. The result depicts that three times client's buffer has its values lower than the preferable buffer length, and decrease of buffer length at 149 seconds represents the aggressive buffer mode that shift the video quality to lowest quality level.



(a) Frame Rate



(b) Video Bitrates

Figure 4: Client Frame Rate and Video Bitrates in WLAN

In case of WLAN, when video dropped frame rate exceed 10% as shown in Figure 4a then client player switches to the lower video quality. The three times dropped of video frames rate result the decrease in video quality as clearly shown by Figure 4b. Initially, the proposed algorithm, selects the lower video quality in order to quickly start the video streaming, but later it mostly plays high quality of available video (i.e. 1700 kbps) as shown in Figure 4b. Whenever, the client experiences the drops in buffer length, subsequently it switches to next lower video bitrates. However, when buffer length decreases lower than the aggressive buffer length then it shifts down to lowest video quality (at 149 seconds) in order to avoid the pausing in the video playback and maximize the user's QoE. Similarly, decrease in maximum available bandwidth, and dropped video frames cause the decrease in video quality.

IV. Conclusion

In this paper, we have proposed a rate adaptive algorithm that adapts the video quality based on dynamic network bandwidth, dropped video frame rate, and user's buffer status. We have evaluated the proposed algorithm in real time dynamic Internet environment with two different client side networks (LAN and WLAN). The proposed algorithm can successfully adapt the video quality by considering the maximum available bandwidth, dropped video frame rate, and buffer length at the client side. The algorithm maximizes the user's QoE by avoiding the stalling during the video playback with efficient bandwidth utilization. In the future, we shall evaluate the proposed algorithm by considering the different client devices (e.g. smart phone, tablet, HD Screen), and observe its influence on user's QoE.

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