Adaptive Modulation and Coding for Multi-Hop Network

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Abstract— *Video transmission over wireless network has got tremendous attention since because of increasing demand for multimedia information and quick growth of wireless network. This paper presents a video transmission over a multi hop network with adaptive modulation techniques. The video packets sent changes in accordance with channel condition and select a suitable modulation technique thus improving the life time of network. Adaptive modulation reduces the bandwidth utilization and energy consumption since it senses the channel condition and switches to the appropriate modulation required at particular channel state. Evalvid tool is used for the video transmission in wireless network. Performances of different modulation like 64-QAM, 16-QAM, QPSK and BPSK are analyzed for the variation of sink node speed and simulation time.*

Keywords - Evalvid, Adaptive Modulation, CSI, BPSK, QPSK, 64 QAM, 16 QAM.

1. INTRODUCTION

In recent years research has been undertaken targeting on improving spectral efficiency so that within given bandwidth higher data rates are achieved. Number of factors that quality of signal received at destination depends in cellular communication system are like distance between desired and interfering base station, long normal shadowing, short term Rayleigh fading, path loss exponent and noise. In the transmission over radio channel, mapping of digital information to analog signal is called as modulation and channel coding is improve in the bit error rate performance, by adding redundancy to the transmitted data. Link adaption is a process in which signal transmitted to and by a particular user is modified for signal quality variation and to improve system capacity [1]. To raise overall system capacity alternative link adaption method is offered by Adaptive Modulation and Coding.

In recent years research has been undertaken targeting on improving spectral efficiency so that within given bandwidth higher data rates are achieved. Focusing on inherent capacity of underlying channel, based on link quality technique which support and adjust to the transmission parameter (in real time) have been proposed. This feature totally called as "Adaptive Modulation and Coding" (AMC) technique and based on the feedback information and in accordance with targeted Quality of Service, they provide the values of transmission parameter to be employed in the following transmission period as output [2]. Full channel capacity utilization can be given in two ways in the presence of multipath fading and interference from other user. They are adaption and diversity technique. Adaption refers to adapting different modulation technique by the transmitter according to channel condition.

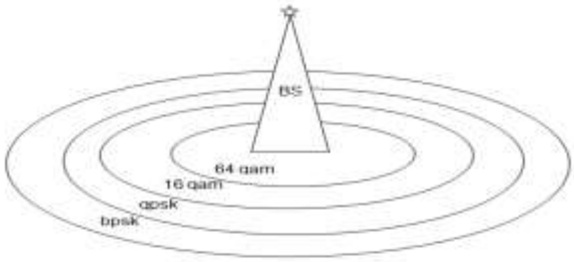

Figure 1: Adaptive Modulation and Coding

Figure 1 shows the illustration of Adaptive Modulation and Coding. As the base station is nearer higher modulations are used and throughput is increased. Lower modulations are adapted as range of communication moves away from the base station. Thus different order modulations are considered by the channel estimation [3].

Modulation techniques are mainly divided as analog and digital modulations. Different types of digital modulation schemas are achieved by the variation of different parameter of carrier signal. Simplest form of digital modulation with two states in carrier signal is called BPSK or also called as 2-QAM technique. Only 1 bit per symbol is modulated in BPSK. QPSK is a quadrature phase shift keying in which 2 bits per symbol are modulated and they are also called as 4-QAM. QAM is a combined form of amplitude and phase shift key. It consists of different order modulations which helps to increase the throughput since more bits per symbol is sent. For 16-QAM 4 bits per symbols and for 64-QAM 6 bits per symbol is sent. In this paper these four modulations like BPSK, QPSK, 16-QAM, and 64-QAM are used and performances are analyzed.

In paper [4] review of various adaptive modulation and coding techniques are done. Various adaptive methods to implement variable rate, variable error probability and variable coding are introduced. Main focus is on variable power techniques in which comparison between two of them like channel inversion and water filling is done. In paper [5] over time varying fading channel, brief survey on adaptive modulation and coding is done. One of the important performance measures like spectral efficiency is explained here. When received signal is not faded modulation technique with high data rate are selected and low data rate modulations are selected when received signal is faded. N-MSK modulation schema is preferred in non-linear channel condition and in linear channel condition N-QAM schema is preferred. In paper [6] adaptive modulation is performed by the use of past channel observation of one carrier to predict future channel state information (CSI).an adaptive Minimum Mean Square Error (MMSE) prediction method is proposed. As a result for designing adaptive transmission for co-related carrier and multi carrier valuable insights is given. In paper [7] with static based routing protocol, performance of video in multi-hop network is done. Parameter of static based routing protocol and impact of video quality during topology change are discussed. Effect of frame aggregation on video streaming performance in IEEE 802.11n is studied in paper [8]. This impact is done in terms of delay and video quality and also showed that even in 6-hop chain full-HD video can be transmitted with excellent quality and delay. Paper [9] deals with adaptive modulation and coding used in WiMax based wireless network. In case of non-line of sight communication this allows to increase the network performance. In terms of error probability and data throughput better performances are achieved by changing modulation order in accordance to the channel condition.

Experimental Environment

A. Evalvid Tool

Over a real or simulated communication network, Evalvid tool gives a complete framework and tool-set for evaluation of video quality transmitted. As QoS parameter like delay, loss rates, and jitter of underlying network is measured, quality of received video based on frame by frame PSNR calculation is supported by evalvid tool. By the tool-set, it is possible to exchange both codec and network at user, as it has modular construction.

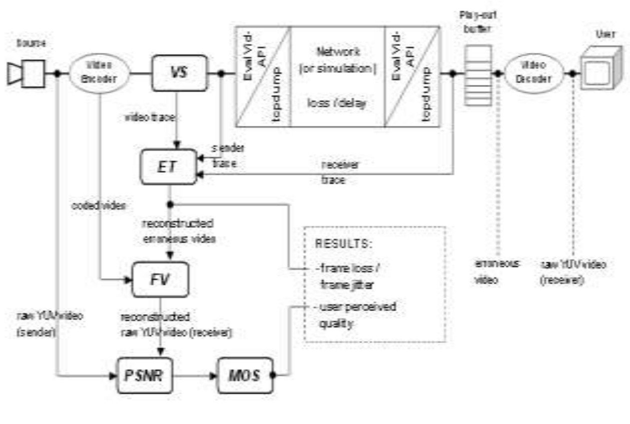

Figure 2: Framework of Evalvid tool

Figure 2 shows the framework structure of Evalvid tool [10]. Interaction between implemented tool and data flows are symbolized. For evaluation some of the data are required from both sender and receiver side. From the sender side data like raw uncompressed video, encoded video, time stamp and type of every packet sent are required. From the receiver side data information like time-stamp and type of every packet received, reassembled encoded video, raw uncompressed video to be displayed are required. Components of evalvid tool are,

- Source: Video files are stored in YUV format which are uncoded.
- Video Sender (VS): Two trace files like sender trace file and video trace are generated for video quality evaluation.
- Evaluate trace (ET): It also uses receiver trace file and generates reconstructed erroneous video.
- Fix video (FV): When lost frames are cannot be provided by used codec, FV is used.
- Peak Signal to Noise Ratio (PSNR) : It is an quality measure which compare signal energy and gives signal to noise ratio.
- Mean Opinion Score (MOS): Is an subjective quality measure ranges from 1 to 5 which is from best to worst.

Some of the tools are also required for the multimedia transmission using evalvid. They are ffmpeg, MP4Box, Etmp4, Mp4trace and Psnr. For ffmpeg, Etmp4, Mp4trace extra software codec and library files need to be installed before. By using evalvid, video quality like packet/frame loss rate, delays, packet/frame jitter, PSNR and MOS metrics are measured [10, 11].

Simulation scenario

Network simulator NS-2.35 is used for the video transmission. MyTrafficTrace, MyUDP, MyUDPSink are the connecting interface between NS-2 and evalvid. Simulation is done for the multi-hop network.

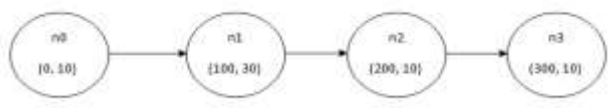

Figure 3: Network scenario

Figure 3 shows the network scenario for the multi-hop network. Four nodes are considered in which video packet from source node n0 is sent to the destination node n3 through the intermediate nodes like n1 and n2. Node movement is considered for n1, n2 and n3. Initial node position is as shown in the figure. After node movement, position of n1 is (999,999), position of n2 is (800,800) and position of n3 is (750,750) with flat grid space of 10000*10000m. Performance is measured by varying node speed and simulation time. For the different node speed and simulation time, performance of modulation like BPSK, QPSK, 16-QAM, 64-QAM are measured. Packet drop time of each modulation is noted and at particular time modulation schema is shifted to lower order to obtain higher throughput and efficiency. Thus Adaptive Modulation method is applied for video transmission for multi-hop network. Modulation schema are defined in the Wireless Phy-Extension header and it is made used by giving Basic Modulation Scheme_0,1,2,3 in tcl script where 0 is for BPSK, 1 for QPSK, 2 for 16-QAM and 3 for 64-QAM.

Results and Discussion

Simulation is done by considering variation in the node speed and simulation time. Here performance analysis is done by considering two simulation time variations. One is for 10seconds and another is for 40seconds. In the first scenario for simulation time 10 seconds, speed of node n1,n2 ,n3 is kept varying for 10, 20, 30, 40, 50, 60, 70, 80, 90 and 100 m/sec. Same steps are followed for second scenario, in which simulation time is kept constant for 40 seconds and result values are calculated by varying node speed.

Performance measures like packet delivery ratio (pdr), throughput, delay and number of packets lost are calculated separately for modulations like BPSK, QPSK, 16 QAM and 64 QAM. Then by considering packet drop time all the performance measures are also done for adaptive modulation. Graphical representations of this performance measure for different modulation and for adaptive modulation are shown below.

Figure 4 and 5 shows the packet delivery ratio of different modulations for the simulation time of 10 seconds. X-axis is given with the values of node speed and y-axis is varied with packet delivery ratio values of bpsk, qpsk, 16 qam and 64 qam. It shows that BPSK, the lower order modulation yield better PDR compared to other higher order modulation techniques.

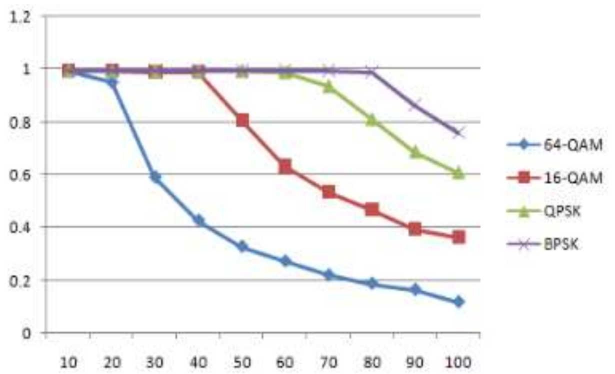

Figure 4: PDR for 10 seconds

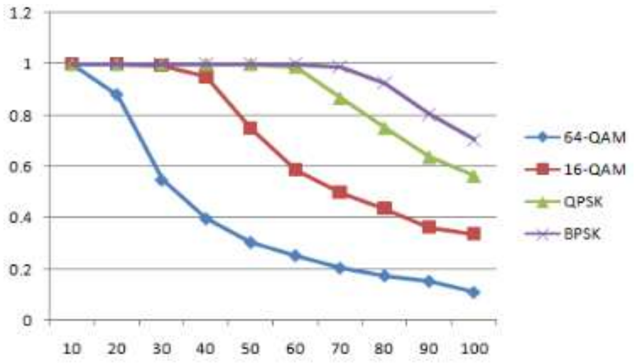

Figure 5: PDR for 40seconds

Figure 6 and 7 shows the throughput variation for simulation time of 10 and 40 seconds. X-axis is given with values of node speed and y-axis with throughput values of different modulation. We observe that BPSK gives 100% throughput compared to other modulation.

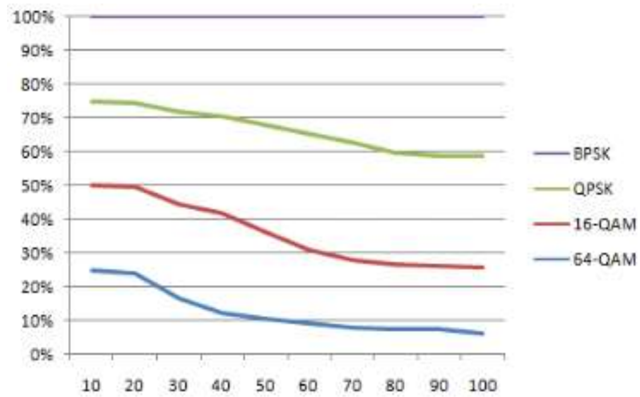

Figure 6: Throughput for 10seconds

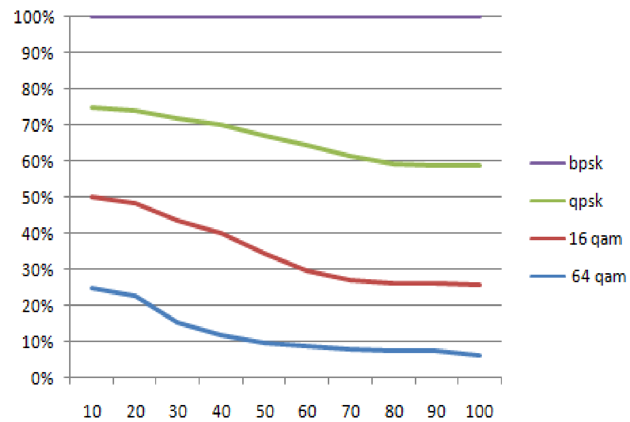

Figure 7: Throughput for 40 seconds

Figure 8 and 9 shows the number of packets dropped for simulation time of 10 and 40 seconds. X-axis is given with values of node speed and y-axis with number of packets dropped for different modulation. We observe that more number of packets are dropped during 64 QAM method.

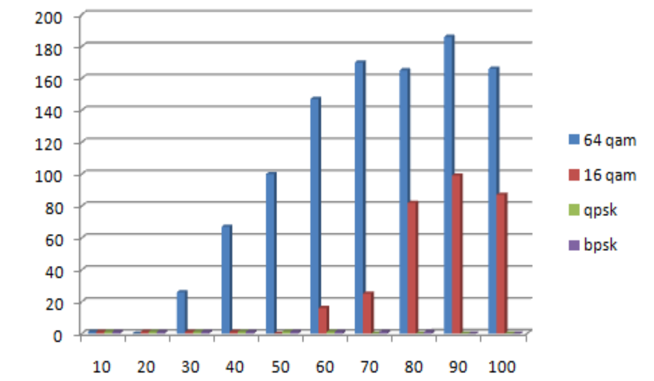

Figure 8: No of packets dropped for 10sec

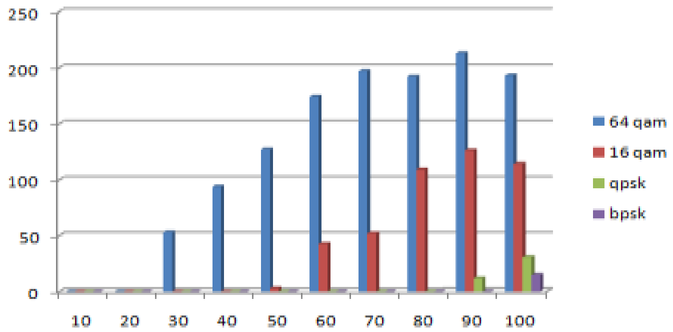

Figure 9: No of packets dropped for 40sec

Figure 10 and 11 shows the graphical representation of delay variation for 10 seconds and for 40 seconds of simulation. X-axis with speed of node is varied in accordance to the delay values for different modulations. Higher order modulation gives larger delay compared to lower order modulations.

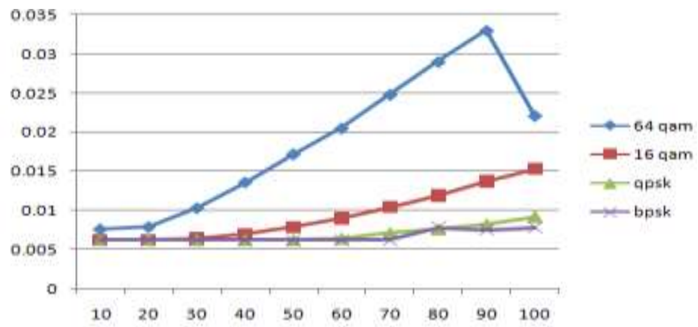

Figure 10: Delay for 10 seconds

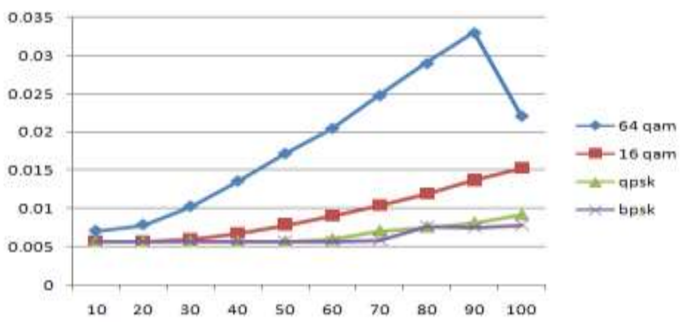

Figure 11: Delay for 40 seconds

For overall adaptive modulation after applying all the modulations by considering packet drop time, gives following results.

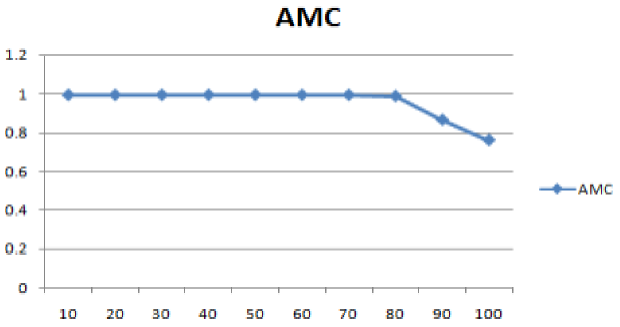

Figure 12: PDR for overall AMC

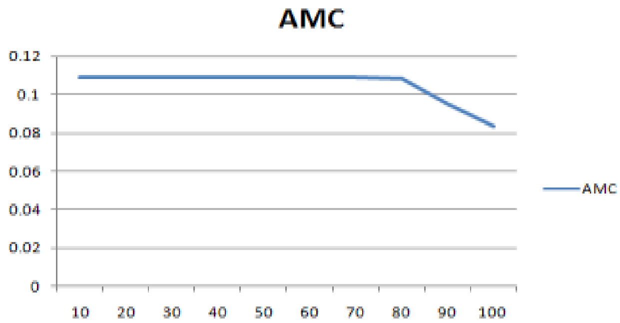

Figure 13: Throughput for AMC

Simulation time is considered for 10 seconds and for Adaptive Modulation PDR, Throughput, Delay and number of packets dropped are calculated. X-axis is varied with the sink node speed from 10 to 100 m/sec.

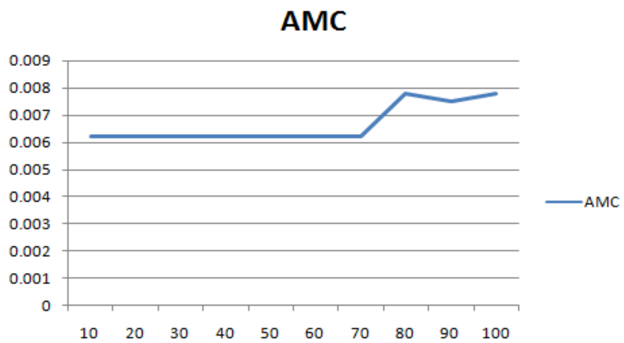

Figure 14: Delay for AMC

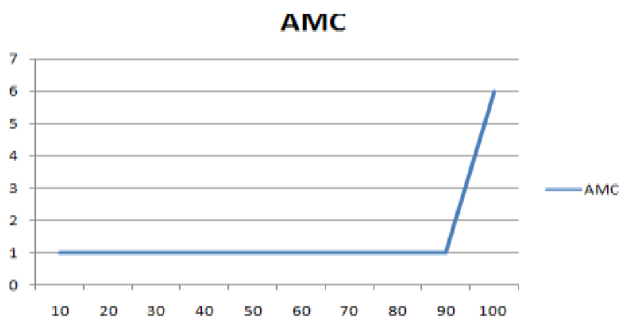

Figure 15: no of packets dropped for AMC

V. Conclusion

To improve overall system capacity, a link adaption method is introduced by Adaptive Modulation and Coding which increases the throughput and spectral efficiency thus improving network lifetime. Video transmission over a network simulator for a multi-hop network with 4 nodes is carried out using a tool called Evalvid. Video quality measure is done by using this tool.

Performance measure like packet delivery ratio, throughput, delay and number of packets dropped is carried out for four different modulations like BPSK, QPSK, 16-QAM and 64-QAM. By the result it is concluded as lower order modulation like BPSK gives better performance compared to higher order modulation. Adaptive Modulation schema is applied by considering packet drop time of each modulation and better throughput is obtained.

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