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Multi-session Packet Scheduling Approaches over Multi-hop Wireless Networks

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Abstract: Wireless Networks make possible many new emerging applications in a wide range of domains. Packet scheduling in multi-hop wireless networks has a significant impact on the overall system performance. This paper analysis the performance of three different packet scheduling methods in multi-session, multi-hop wireless networks.

Keywords: multi-hop, multi-session, packet scheduling, wireless networks.

I. INTRODUCTION

Packet scheduling in wireless networks is considered as an important key part to guarantee the Quality of Service (QoS) that whilst maximizing the available system capacity. The objective of resource sharing algorithm is to provide the resources and transmission power to the multiple users in communication and to optimize the metrics like throughput, delay or outage probability [1].

Wireless communication is able to harvest energy from the environment. While energy-efficient packet scheduling policies are well investigated in the existing battery powered systems, energy efficient packet scheduling in the energy harvesting networks are used in applications recently [2]. Energy harvesting transmitters used in single user communication system is developed with a packet scheduling scheme that minimizes the time of transmission of packets to be delivered to the receiver.Packet scheduling and policing mechanisms are very important for providing QoS to networked multimedia applications. The manner in which the queued packets are selected for the next transmission on the link is the packet scheduling discipline. Communication of multimedia applications requires the video compression and networking. So the importance of research in the field of multi-session video transmission is increasing day-by-day. Also, the transfer of such packets is a challenging task because the compressed packets are sensitive to transmission errors [12]. The rest of the paper is organized as follows. Section 2 reviews about the related literature and section 3 describes the packet scheduling methodologies for multi-session video streaming for multimedia applications. Section 4 details the performance evaluation of various packet scheduling model, and finally conclusion and future scope is given in section 5.

II. RELATED WORK

In this section, we review the prior work on packet scheduling over various applications. Masoomeh et al [3] presented the network resource allocation in multiuser downlink wireless systems where the base station and the mobile stations are equipped with multiple antennas to provide fair and efficient transmission services to the mobile users. Importance is given to packet scheduling that has good impact on the overall performance of the Multiple Input Multiple Output (MIMO) system. The proposed novel scheduler makes use of a flexible packet transmission algorithm. The scheduler provides high performance in terms of low average packet transmission delay and time and service fairness. Song et al [4] presented that the transmitter decides which set of receivers to serve in the slots to maximize the average data rate realized by the receiver. The proposed scheduler is able to provide fairness and has low average packet transmission delay. Scheduler assigns high priority to transmission-rate users with proper traffic management and the packet delay is related to the user traffic arrival and the packet length. Yuanye et al [5] proposed a carrier load balancing and packet scheduling methodology for multi-carrier systems. The proposed packet scheduling algorithm improves the coverage performance and the resource allocation fairness among the users compared with the independent scheduling for component carriers. The proposed scheduling algorithm improves the coverage gain up to 90 percentages with no loss of the overall cell throughput. Zeng [6] presented the performance of the frequency domain packet scheduling for Long Term Evolution (LTE) downlink. Analysis is done with the downlink OFDMA system-level performance of Frequency Domain Packet Scheduling (FDPS) under the assumptions of partial Channel Quality Indicator (CQI) feedback available from the terminals. An Outer Loop Link Adaptation (OLLA) is used to stabilize the first transmission Block Error Probability (BLEP) as a practical remedy against link adaptation errors.

Mary et al [7] proposed a packet scheduling strategy in sensor networks with Stop and Go Multi-Hop (SGMH) protocol. The recovery of data through retransmission should be minimized due to the stringent requirements on the worst case time delays. SGMH is a distributed multihop packet delivery algorithm and the fractions of the total available bandwidth on each channel is assigned to several traffic classes by which the time is takes to traverse each of the hops from the source to the destination.

Hailun et al [8] presented a congestion based opportunistic packet scheduling algorithm with variable size packets

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support in ad hoc networks. In this algorithm, the sender sends multicast RTS frame targeted to several next-hop receivers, and the receiver will reply with priority-based CTS by the probability according to the queue congestion level, and reservation sub-header is added to DATA frame to support variable packet size. Dario et al [9] analyzed the energy efficient packet scheduling algorithms for the LTE system with the state of art schedulers a dynamic system level simulator.

Energy efficient metrics are used to compare the different schedulers from energy efficiency. Simulation results show good performances in terms of both spectral and energy efficiency and the counterpart is offered by the fairness provided by the different standard algorithms. Jing et al [10] investigated the transmission completion time minimization problem in a two user Additive White Gaussian Noise (AWGN) broadcast channel, where the transmitter is able to harvest energy from the environment.

The goal is to minimize the time by which all the packets are delivered to their respective destinations. By analyzing the structural properties of the optimal transmission policy, proved that the optimal total transmit power has the same structure as the optimal single user transmit power.

Nan et al [11] proposed an adaptive cross-layer design for the downlink multiuser orthogonal frequency division multiplexing systems to maximize the weighted sum capacity of all users, where each user has multiple heterogeneous traffic queues simultaneously. The scheduling scheme is employed at the MAC layer, which determines the packet transmission order by assigning different weights to different packets. The cross-layer design requires lower overall complexity than the conventional queue based designs.

III. PACKET SCHEDULING METHODOLOGIES

Various packet scheduling algorithms are available for multi-session transmission over multi-hop wireless networks. The objective of communication in the multi-session packet scheduling algorithm over multi-hop wireless networks is to maximize the QoS.

The QoS is analyzed indirectly by the measured metrics like throughput, delay or packet loss. The quality of the packet at the receiver also depends on the different levels of contribution on the various video packets. This session discusses about three packet scheduling algorithm.

A. Priority Queuing Packet Scheduling

Applications like video streaming will require different levels of packet or frame scheduling approaches. The application mentioned in [13] is organized based on the importance of different levels in a hierarchical approach.

To improve the video quality the packets are classified into different priority class or different quality layers. The packet priority is calculated using an exponential method.

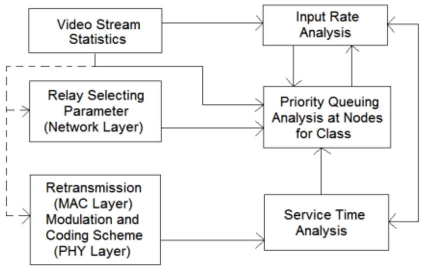

Figure 1 Priority Queuing Analysis System Map

Figure 1 shows the priority queuing made at each intermediate node in the WSN with multimedia applications [15]. The service time of packets in a class is obtained by the relay selecting parameters of the network layer, and retransmits strategy at the MAC layer. This also depends on the modulation and coding scheme at the PHY layer. The packets in a class obtain a steady state waiting time distribution for all the multimedia based video priority classes. A packet of class is routed from its source through an intermediate node with a percentage towards its destination. Each intermediate node contains a queue that schedules the waiting packets based on the header information and delay deadline [15]. Modulation and coding strategy of the intermediate node changes depending on the status of the corresponding link.

B. Content Aware Packet Scheduling

Hybrid video encoders like H.264 and MPEG4 are used for recent video encoding and communication [14]. This system contains multiple video sequences and is packetized into multiple data units. All the units are independently decodable and represent a slice of the video, which is small as a group of few macroblocks or large as an entire video frame [16]. Figure 2 shows a multiuser system for downlink video streaming. When the video stream is received by the scheduler, the scheduling rules are accompanied on other traffic by assigning different utility functions. The scheduler uses three features on each packet to allocate the resources across the users. The features include the utility gain due to packet transmission, packet size in bits, and decoding deadline for the packet [16]. Packets that are available in the transmission queue after the decoding deadline is dropped. Then the error in the decoding image is identified due to the packet loss in wireless channel. The errors are normally covered by an error concealment technique using spatial and temporal correlations.

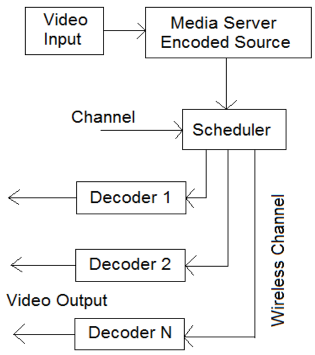

Figure 2 Multiuser System for Downlink Video Streaming

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C. Content and Deadline Aware Packet Scheduling

This scheduling is designed for multi-session video streaming over multi-hop mesh networks. The scheduling algorithm considers content priority of video packets, queuing delays, and dynamic network conditions. Figure 3 shows the packet scheduling in an intermediate node that receive packets from incoming links and store them in the buffer for forwarding. As the buffer size is finite, and it exceeds the maximum limit, the packets with the least scheduling priority are dropped.

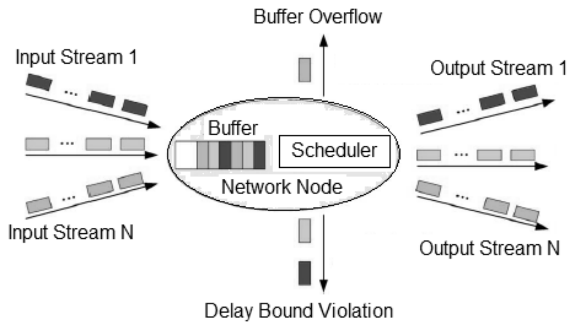

Figure 3 Packet Scheduling in an Intermediate Node

The scheduler based on the priority of the packet decides which packets in the buffer to transmit or drop. The video related packets are provided with high priority so that high preference is given for such packets. The system to provide reservation and preference is maintained by a central coordinator in the multi-hop network [17].

IV. PERFORMANCE EVALUATION

The video sequences are encoded using MPEG-4 with a Quantization Parameter (QP) of 8, a Group of Picture (GoP) size of S as 15, in which one I frame followed by fourteen P frames, and an intra refresh ratio of 10 percentage. The test has been carried out for eight different video sequences: Mother and Daughter, Carphone, Foreman, Coastguard, Salesman, Akiyo, News, and Table tennis, which have a different range of characteristics. The normalized transmission distortion as the measure of content priority P_c is given by,

$$P_{c\,(k,\,i)} = \frac{D_{t(k,i)} - D_t^{min}\,(k)}{D_t^{max}\,(k) - D_t^{min}\,(k)} \qquad (1)$$

where, $D_{t(k,i)}$ is the transmission distortion of the i^{th} video packet in the k^{th} video session. $D_t^{max}\,(k)\ and\ D_t^{min}\,(k)$ are the maximum and minimum transmission distortion of video packets in the session respectively.

V. CONCLUSION

In this paper, three different multi-session packet scheduling approaches over multi-hop wireless networks are analyzed. These approaches are used for effective resource utilization and scheduling over video streaming applications. Further study can be made to temporal and quality scalable bit streams to the partially transmitted video packets.

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