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Queue-Based Traffic Regulation on Wireless 802.11Networks

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ABSTRACT: The new multimedia applications (videoconferencing, VoIP, IP-TV etc) and real time applications require high throughput and reduced delays. The current ad hoc networks are not able to satisfy the requirements of quality of service (QoS) upto the required extent. In WLAN, the Access Point plays an important role for improving QoS. Acombination of Deficit Round Robin (DRR) and Admission Control Algorithm (ADC), to be employed at Access Point (AP), help to enhance the QoS.The proposed scenario considers a mix of Transmission Control Protocol (TCP) and User Datagram Protocol (UDP) flows. The DRR scheduling algorithm along with admission control can achieve high throughput while maintaining low delay for real time applications.Hence, the proposed system will present a simple approach to enhance the Data, Voice, and Video performance over the 802.11 WLAN by using some special queues. This requires the system to first identify the type of service (real time / non-real time) and then use the appropriate scheduling algorithm. Simulations were made under Network Simulator (NS2).

Keywords: WLAN, Multiple Queue, QoS, Scheduler, NS2

I. Introduction

Nowadays, multimedia and real-time applications consume much network resources and so, need high flow rates and very small transfer delay. Hence, improving QoS of real time applications is a subject of demanding research. Quality of Service (QoS) is characterized by a certain number of parameters (throughput, latency, jitter and loss, etc.) and it can be defined as the degree of user satisfaction. The basic problem with the existing WLAN based voice and video is discontinuous flow of real time traffic, which degrades the Quality of Services for voice and video system. Wireless APs are “smart middle” devices with a potential to meet most of the QoS requirements. The traffic that goes through the wireless APs is dynamic and is not always the same mix of applications. These limitations have encouraged research in classification of flows to provide specific QoS needs for them. Classification of flows removes the need for users to configure their wireless APs to prioritize their traffic. Instead wireless APs examine the flows and classify them automatically. Once classification of flows takes place, flows are treated according to the class in which they are placed. The goal is to improve overall quality of Real time (RT) applications (i.e. multimedia applications) by managing queues at the wireless AP.

In this paper, we compareDeficit Round Robin (DRR) scheduling scheme [2] which gives better results than the original Dual Queue(DQ) scheduling scheme [1] with respect to the set of QoS parameters, to be employed at the Access Point (AP) for fair and efficient access provisioning.The DRR scheme suggests that the performance of real time applications can be enhanced. To validate the solution, simulations were made using Network Simulator (NS2). We measure throughput and delayby varying the number of flows.Considering the practical requirements, the simulation scenario is designed. The simulation scenario consists of five mobile nodes and three APs. The parameters in NS2 have to be assigned appropriate values so that it will simulate the practical scenario.

II. Literature Survey

The MAC Layer is one of two sub layers that make up the Data Link Layer of the OSI model. The MAC Layer manages and maintains communications between802.11 stations (radio network cards and access points) by coordinating access to a shared radio channel and utilizing protocols that enhance communications over a wireless medium. Various methods have been proposed to carry out prioritized transmission of traffic. Some of the researchers have used various strategies to enhance the real time services.

Jian-ming, Zhan Shi Xian, and Zhao Xu Dong [6] have designed an efficient Centralized Scheduled Access MAC approach in IEEE 802.11 to satisfy multimedia traffic mix. They have used two main algorithms; one is queue management algorithm for downlink and uplink that satisfies video traffic's high bandwidth requirement and second is polling list management method to enhance the efficiency of the polling scheme for transmitting voice traffic. With the

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help of simulation, they have proved that the mean delay of voice and video can be decreased and data throughput can be increased. But the system can further be improved. In their simulation, the video traffic model is constant bit rate. To confirm the real world, one can use variable bit rate video traffic model.

Alessandro Andreadis et al [5] mentioned the method of fine-tuning the parameters that can regulate the Enhanced Distributed Channel Access (EDCA) MAC. This scheme is used to achieve high performance in terms of throughput and delay, allowing multimedia traffics to fully satisfy their QoS requirements. Simulation results were analyzed and compared for heterogeneous traffics (voice, video and ftp), both in IEEE 802.11b and IEEE 802.11e WLAN.

Xiang Chen et al [7] described Enhanced Distributed Channel Access (EDCA) mechanism that can support prioritized QoS, however, it cannot guarantee strict QoS required by real-time services such as voice and video without proper network control mechanisms. Hence an analytical model was built to derive an average delay estimate for the traffic of different priorities in the unsaturated 802.11e WLAN, showing that the QoS requirements of the real-time traffic can be satisfied if the input traffic is properly regulated. It uses the admission control and rate control algorithm.

In [1] Jeonggyun Yu et al have proposed a dual queue scheme, which implements two queues in the device driver of the 802.11 MAC controller so that a packet scheduling, based on a strict priority queuing, can be conducted at the driver level to prioritize the VoIP packets. Similarly dual queue scheme can be used for better performance of video and other real time traffic.

In [2] Wan Quan, Du Ming Hui have proposed Deficit Round Robin (DRR) polling scheduling algorithm, which provides more efficiency for the Access Point (AP) to poll the VoIP stations. Simulation results have shown that the proposed algorithm can improve QoS of VoIP application over WLAN by providing lower access delay and higher throughput.

P. Chatzimisions et aldescribe a simple admission control algorithm [3] that is based on throughput analysis of IEEE 802.11 DCF with variable packet length under saturation conditions. The admission control algorithm is based on the minimum throughput that a single station of a WLAN is required to have, in order to fulfill the application's throughput requirements.

M. Shreedhar and George Varghese [4] have described DRR algorithm which provides isolation of packets at very low implementation cost. It requires only O(1) work to process a packet and is simple to implement in hardware. Memory requirements are also less. DRR requires quantum size to be at least a maximum packet size because it affects delay bounds.

III. Need of Present Work

From the above literature review, one can conclude that the RT and NRT traffic cannot coexist harmoniously over the WLAN.Following are the points which were felt to be considered while handling RT and NRT services:

1) During network congestion, routers, access points and switches can overflow their queue buffers and can be forced to discard packets. Packet loss for NRT applications, such as web browsers and file transfers are undesirable but not critical.
2) The protocols used by NRT applications, usually TCP, are tolerant to some amount of loss because of their retransmission capabilities. RT applications based on the UDP are significantly less tolerant to packet loss.
3) The real time traffic requires continuous transmission of packets to have better QoS for applications such as voice and video so that the unbreakable real time transmission can be achieved.
4) IEEE 802.11e to can improve QoS of RT applications. 802.11e emphasizes on a set of QoS enhancements for WLAN applications through modifications to the MAC layer. But the results obtained by 802.11e can be further improved by using a software upgrade based approach. Managing the software queues is easy rather than changing MAC layer.
5) Scheduling algorithms play an important role in enhancing the QoS of RT applications.

The priority queue mechanism is well suitable for WLANs. In environment with heterogeneous traffic such as video, voice and data how to extend the dual queue approach and assign priorities to different categories is a very challenging issue. Taking into consideration the above limitations, need was felt to design and implement multiple queue scheme depending on priority for faster data transfer.

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IV. SYSTEM DESIGN

The aim is to improve the QoS of Real time applications than non-real time applications in WLAN. The problem of the inability of real time and non-real time traffic to coexist harmoniously can be solved by simple solution that requires only change to the MAC protocol at the Access Point. The MAC protocol at the wireless end stations need not be modified, making the solution more readily deployable over the existing network infrastructure.In order to sort out these issues and improve the QoS in WLAN the Dual Queue (DQ) and Deficit Round Robin (DRR) schemes have been simulated for a typical scenario by varying various parameters. In order to fulfill the objective the work has been divided into the following modules.

Module 1: Identify packet type and classify them accordingly (Data/Video/Audio)

This module focuses on the method to classify packets according to their type. Packets are classified as RT and NRT using the payload type field in packet format. After classification packets are enqueued into the appropriate queues. There is a default mapping of payload type codes to payload formats.

Module 2: Design and simulate the traffic flow in network by using special queues on top of 802.11 MAC controllers

The present work is to use the dual queue scheme (DQ) [1] and deficit round robin (DRR)algorithm [4] along with admission control algorithm [3] to improve the QoS of real time traffic.The scheduling algorithms will be simulated using Network Simulator (NS2) [9]. Dual queue schemeimproves the QoS of VoIP applications (RT applications) which are delay sensitive. It uses strict priority queuing. This scheme implements FIFO queues inside the AP. These queues are implemented above the 802.11 MAC controllers, i.e., in the device driver of the 802.11 NIC, so that packet scheduling can be performed at the driver level. MAC controller cannot be modified by people other than the corresponding chip vendor. A packet from the higher layer is processed for the header and is forwarded to the MAC controller for the transmission. One of the two queues is dedicated to hold RT packets and other for NRT packets. Packets after classification are enqueued in appropriate queue, i.e., RT packets in RT queue and NRT packets in NRT queue. NRT queue is never served as long as the RT queue is not empty.

Deficit round robin (DRR) modifies Weighted Round Robin (WRR) [8] to allow it to handle variable packet sizes in a fair manner. The basic idea is to use round robin with a quantum of service assigned to each queue. The only difference from traditional round robin is that if a queue was not able to send a packet in the previous round, packet length is added to the quantum for the next round. Thus, deficits are recorded. Queues that were shortchanged in a round are compensated in the next round.

Admission control is the process of regulating traffic volume in wireless mobile networks. Admission control can be used to ensure or maintain a certain level of quality in communication networks or a certain level of performance in internet nodes and servers where RT (multimedia) traffic exists. To have efficient scheduling in wireless networks, we have to combine scheduling algorithm with admission control. Deficit round robin algorithm provides lower access delay and higher throughput in case the number of STAs increased rapidly and admission control system guides us to maintain the throughput in case of any number of multimedia (RT) stations and data (NRT) stations. So here we combine both the algorithms in order to increase the throughput and lower the packet delay to increase the QoS.

Considering the scopes of two algorithms, the admission control algorithm should be implemented first in order to determine the admission of particular station. After deciding this we implement deficit round robin to set the priorities to RT and NRT packets in order to increase the QoS.

Module 3: Analyzing the results of the two scheduling schemes and proposing a suitable one based on the outcome, which is dependent on the parameters like delay, throughput and thereby check for increase in the throughput of the wireless device.

V. SIMULATION SETUP

Simulations are carried out in ns-2 in order to evaluate the performance of the DQ and DRR schemes. We consider a network topology with five mobile nodes and three access points. The data connections use either UDP or TCP. All the stations are assumed to have 802.11b PHY using 11Mbps and 6 Mbps as the data and basic rate respectively. The packet size is 2000 bytes for all flows. We tested the performance of DQ and DRR when the numbers of active flows vary. The average delays that realtime connections experience are evaluated. The results clearly indicate that the DRR scheme enhances the performance of RT applications than DQ scheme.

The figure 1 shows snapshot of simulation scenario which contains total eight nodes. The nodes 2, 3, 4 act as Access points. The interface queues at nodes 2, 3 and 4 use either DQ or DRR scheduling scheme based on the parameter passed while running the simulation. Interface queues of the remaining nodes use DQ algorithm.

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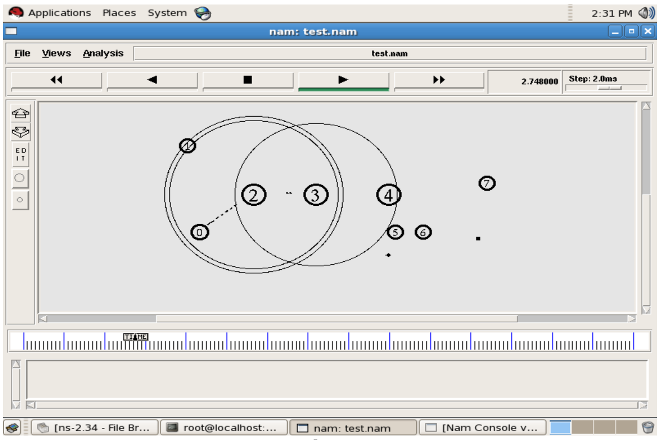
Fig. 1 Simulation Scenario

Following features have been designed using tcl script:

1) Flat topology is created by specifying the length and width of the topography.
2) The time for which the simulation should run is defined in tcl script.
3) This script defines a simple topology of eight nodes, and two agents, a UDP agent with a CBR traffic generator, and a TCP agent with FTP traffic generator. CBR traffic is considered as RT flow whereas FTP traffic is considered as NRT flow.
4) UDP connection is setup from node 1 to node 7 and TCP connection is setup from node 0 to node 6.
5) While running the simulation, the number of RT flows, NRT flows and the scheduling scheme to be used at AP is passed as parameters.
6) The simulation runs for 15s.
7) The output is two trace files, test.tr and test.nam.
8) When the simulation completes at the end of 15s, it will attempt to run a nam visualisation of the simulation on screen.

Admission control mechanism is embedded in the implementation of DRR scheduling algorithm. Trace files are analysed using awk scripts. There are certain default assumptions made during simulation and certain parameters are assigned specific values for simulation. Table I shows the simulation parameters and their corresponding values.

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TABLE I
SIMULATION PARAMETERS

Sr. No.	Parameter	Value
1	Bandwidth	11 Mbits/sec
2	Packet delay	10ms
3	Number of nodes	8
4	Packet size	2000 bytes
5	Queue size	1500 max packet in ifq
6	Channel	Wireless
7	Propagation	TwoRayGround
8	MAC Type	802.11
9	Antenna	OmniAntenna
10	Admission Control Threshold	90% utilization
11	Rate	11 mb
12	Interface Queue Type	Drop Tail (DQ) / DRR
13	Routing Protocol	AODV
14	Applications	FTP over TCP CBR over UDP
15	Simulation time	Start at 2.5 ms Stop at 9.0 ms

VI. SIMULATION RESULTS

This section highlights on the results obtained by running the simulation of the scheduling schemes. The simulation work was done as per the scenario discussed earlier. It also focuses on the graphs obtained from the results for throughput and delay.

Figure 2 depicts the graph of results obtained for throughput of DQ and DRR scheme using single Access Point. The graph shows throughput of real time and non real time data as the number of flows are increased. It can be seen that the value of the throughput of real time data using DRR scheme is higher than the throughput of real time data using DQ scheme.

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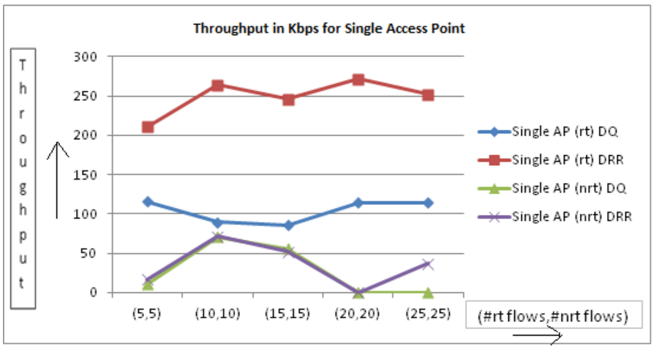

Fig. 2 Throughput in Kbps at Single AP for RT and NRT flows using either DQ or DRR scheme

Throughput is calculated in Kbps for three access points by varying number of RT and NRT flows. Simulations are run for three access points, once using DQ algorithm and then using DRR algorithm Figure 3 depicts the graph for throughput calculations for three access points.

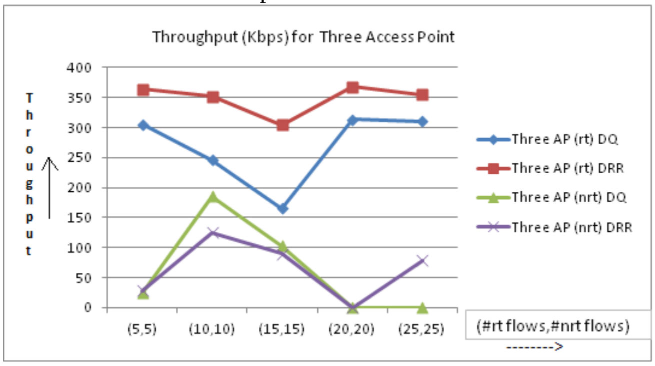

Fig. 3 Throughput in Kbps for three AP for RT and NRT flows using either DQ or DRR scheme

The graph shows throughput of real time and non real time data as the number of flows are increased. It can be seen that the value of the throughput of real time data using DRR scheme is higher than the throughput of real time data using DQ scheme even in case of three access points.

Next the throughput in Kbps is calculated for single access point by varying number of RT and NRT flows when the peak utilization is 70% and 90%. Simulations are run for single access point using DRR algorithm. These results are obtained for a single AP. From graph in figure 4 it is clear that the throughput of real time data when threshold value is 0.7 (peak utilization 70 %) is higher than the throughput of RT data when the threshold value is 0.9 (peak utilization is 90%). Thus it can be seen that by applying admission control we can maintain the throughput in case of heavy traffic.

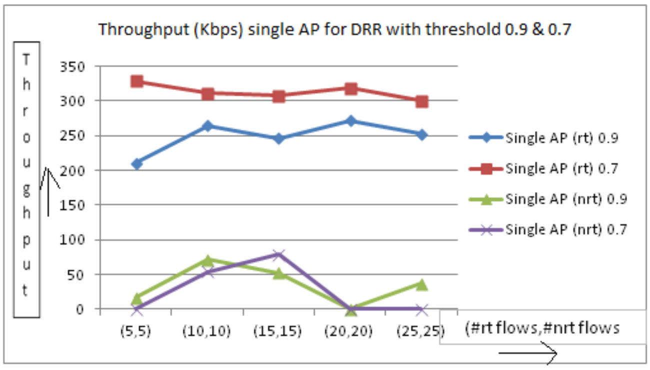

Fig. 4Throughput in Kbps for Single AP for RT and NRT flows using DRR scheme with threshold 0.9 and 0.7

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The throughput in Kbpsis calculated for three access points by varying number of RT and NRT flows when the peak utilization is 70% and 90%. Simulations are run for three access point using DRR algorithm.

These results are obtained using three Access Points. From the graph in figure 5 it can be seen that the throughput of real time data when threshold value is 0.7 i.e. utilization is 70 %, is higher than the throughput of RT data when the threshold value is 0.9 i.e. utilization is 90%. Thus it can be seen that by applying admission control we can maintain the throughput in case of heavy traffic.

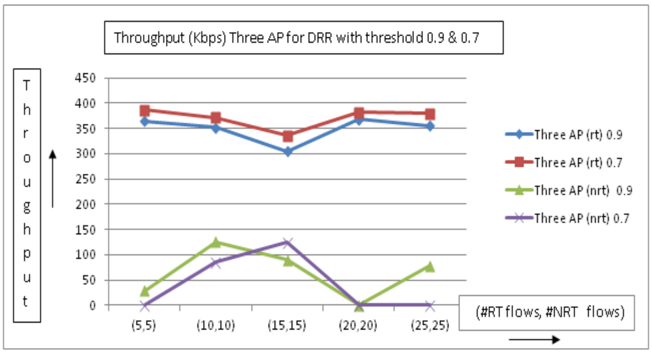

Fig. 5: Throughput in Kbps for Three AP for RT and NRT flows using DRR scheme with threshold 0.9 and 0.7

The average delay is calculated for the system using DQ algorithm and DRR algorithm. From the values it is clear that the delay has been minimized up to some extent using DRR algorithm.

Figure 6 shows the graph for the average delay. It shows different results of access delay when the number of flows are changed in the simulation. It can be seen that the access delay is less using DRR algorithm than using DQ algorithm.

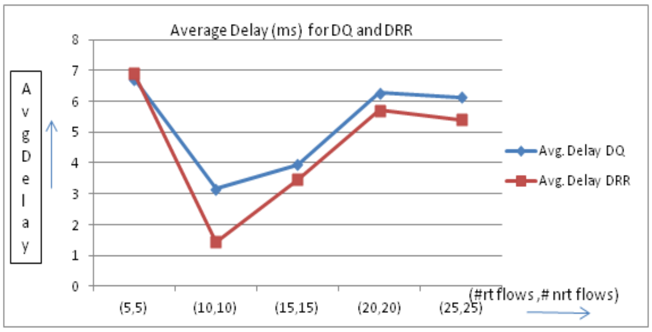

Fig. 6Average delay in ms for DQ and DRR schemes

Graph in figure 7shows the average delay calculated for the system using DRR algorithm by varying the percentage of peak utilization. It depicts that there is no much difference in the result. The delay does not increase even though the peak utilization is less. The numbers of flows are changed in the simulation and the algorithm used is DRR. It can be seen that the average access delay remains uniform even when the utilization is low.

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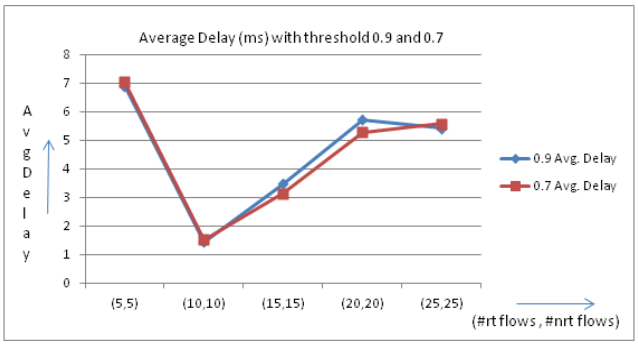

Fig. 7 Average delay in ms for DQ and DRR schemes for peak utilization 0.7 and 0.9

Through a simulation study, we demonstrate that DRR-based scheme provides simple and effective application quality improvement. The graphs demonstrate the significant improvement in quality of RT applications in the presence of delay-insensitive applications.

VII. CONCLUSION

Today we have to process real time and non real time data through single queue, which causes low quality of service for real time applications such as Voice over IP. Maintaining two separate networks for real time applications (multimedia applications) and non real time applications is not economical. If the RT and NRT packets are separated and processed through prioritized multiple queue strategy, then it is possible to improve the QoS for RT applications.

From the simulation results we can conclude that DRR-based queue management provides better quality for real time applications in WLAN with minimal configuration and without changes to end hosts.

Detailed analysis of delay and throughput by using DQ and DRR schemes has been done. The simulation results have shown that the proposed scheme can improve the real time application's performance in terms of low delay and higher throughput compared to the dual queue scheme while preserving the implementation simplicity. The proposed DRR scheme makes use of DRR scheduling algorithm along with the admission control algorithm.

The main contribution of this dissertation is the design and simulation of the DRR based scheduling of packets at AP to improve the quality of RT applications (multimedia applications) which are delay sensitive in WLANs.

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BIOGRAPHY

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