Service Based Packets Scheduling for QoS of Mixed Mobile Traffic in Wireless Network

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Abstract. Nowadays, a number of mobile users who use various mobile traffics are increasing rapidly in wireless environment. There are many researches concerning with traffic scheduling methods in order to have efficient Quality of Services (QoS) mechanisms for mobile users in Wireless Local Area Network (WLAN). The optimal traffic scheduling of mobile networks for various mixed traffic application is a challenging problem. Therefore, in this paper, a framework with a new scheduling method in WLAN, a two-step traffic scheduling method is proposed to satisfy efficient some QoS parameters: throughput, fairness and delay for mixed applications such as real time and non real time traffic in multicast and unicast applications. In the first step, service based scheduling adaptively balances between unicast and multicast applications and in the second step, compound scheduling combines Proportional Fair (PF) for non-real time traffic (NRT) and Delay Threshold (DT) Scheduling for real time traffic (RT).

Keywords: Quality of service · QoS · Wireless local area network · WLAN · Proportional fair scheduling · PF · Delay threshold scheduling · DT

1 Introduction

With the growing increases of internet users and their demands, the network shared the bandwidth among multiple traffic applications which consumes lots of network resources, namely, web browsing, email, voice data, and video in the wireless networks such as Wi-Fi and cellular networks is being paramount. Although many researches [1] focus on improving QoS with scheduling algorithms such as Proportional Fair, Round Robin, Opportunistic which emphasis only on each function such as throughput, fairness, delay, the resources sharing problem and the requirements of multimedia applications [2] and [3] for various mobile users are remained in wireless environment. Moreover, there are also drawbacks for employing isolated scheduling police to handle just RT or NRT traffic or employing mixed scheduling polices to handle both multicast and unicast traffic or both RT and NRT traffic.

Under isolated scheduling police, while simply considering guaranteeing delay for RT traffic, the policy will weak the target of throughput maximization and while simply considering maximizing the system throughput in a fair way for NRT traffic, the policy will ignore delay constraint on RT packets. In case of high probability of QoS violation, enjoying multimedia services will not be possible. Under mixed scheduling policies [4], although the system's throughput seems to be maximized for a

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NRT application and packets delay seems to be minimized for a RT application, the system cannot still solve to be fairness and traffic management problem for them and multicast and unicast traffic in the same Access Point (AP) or Base Station (BS).

Therefore, in this paper, QoS is considered as a main issue for mixed mobile traffic to be fairness and to arrive at their destination on time with the least delay and maximum throughput, limiting the throughput of users close to AP. It proposes two stages scheduling algorithms, namely, service based queuing and compound scheduling that can adapt four mixed traffic types such as RT multicast, NRT multicast, RT unicast and NRT unicast to get better traffic management and scheduling technique solving their QoS requirements in WLAN.

2 System Design

In wireless systems of mixed traffic, how to design the packet scheduling algorithm to guarantee QoS requirements by providing methods of resource allocation and multiplexing at the packet level [8] is not only an important problem, but also a complex problem. Therefore, we analyze many queuing algorithms such as Round Robin (RR) [5] and [6], Strict Priority (SP) [6] and Class Based Weighted Fair Queue (CBWFQ) [7] and so on to solve above requirements.

Considering drawbacks of queuing algorithms, we consider Service Based Priority RR (SBPRR) and Service Based RR (SBRR) scheduling algorithm is proposed by contributing RR scheduling with priority or without priority based on multicast and unicast services solving the drawback of CBWFQ [7] and SP, which solves traffic management issue in order to improve the QoS of mixture traffic and meet fairness for multicast and unicast queues. The system presents a high level overview of three major parts: classification, the service based scheduling and the compound scheduling with priority value for a solution to QoS problem with an optimal resource allocation of mobile users.

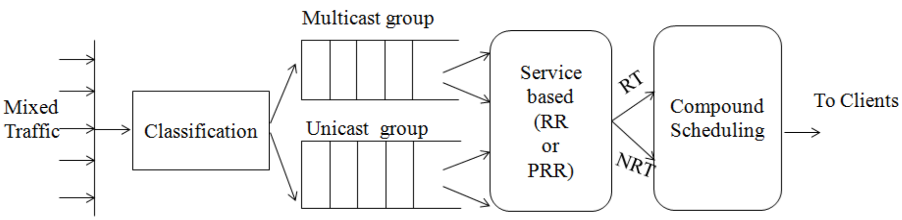

Fig. 1. Detail system architecture

In the detail system architecture in Fig. 1, it classifies incoming mixed applications according to their different parameters into two services such as multicast and unicast queue in which each has RT and NRT traffic due to mixed traffic of mobile users in WLAN simultaneously. Multicast types in the system are video streaming and News. Voice and web browsing belong to unicast type. Then, it fairly schedules each queue depending on priority scheduling methods such as SBRR or SBPRR for different scheduling time interval. Next, compound scheduling calculates priority of mixed RT and NRT traffic of mobile users for fair resource allocation.

3 First Stage Scheduling for Multicast and Unicast Stream

In first stage, it schedules queues of multicast and unicast services for mobile users who operate with heterogeneous mobile traffic to be fairness using SBRR or SBPRR scheduling algorithm. For queue fairness, the delay is unbalanced depending on the number of packets in multicast and unicast queue because resources are distributed unfairly. While multicast queue needs to send many packets to more than one node, unicast queue send only one packet to each node at a time. The unbalanced multicast and unicast queuing delay decrease the QoS of multimedia traffic for mobile users [9].

The dominant component of delay is on the queuing delay by considering the transmission delay and the transmission overhead are very small. Furthermore, the transmission delay will be the same for queues that use the same transmission rate. Therefore, we need to compute the queuing delay by multiplying the transmission time with the queue size according to little's law $D_{system} = Q_{system} / \mu_{system}$ [10] to balance multicast and unicast queue. Let it be the queuing delay of the multicast D_M and the unicast D_U, multicast transmission rate μ_M, unicast transmission rate μ_U as follows:

$$D_M = Q_M \cdot \frac{1}{\mu_M} \tag{1}$$

$$D_U = Q_U \cdot \frac{1}{\mu_U} \tag{2}$$

Where, $\mu_M = P.\mu_U$ which means the multicast transmits P packets at a time interval while unicast transmits only one packet. Thus, D_M can be rewritten as:

$$D_M = Q_M \cdot \frac{1}{P.\mu_U} \tag{3}$$

Then, we get the optimal P value for balancing the delay of both queues as follows:

$$D_M = D_U \tag{4}$$

$$Q_M \cdot \frac{1}{P.\mu_U} = Q_U \cdot \frac{1}{\mu_U} \tag{5}$$

Then,

$$P = \frac{Q_M}{Q_U} \qquad \text{If } Q_M \neq Q_U \tag{6}$$

$$P = 1 \qquad \text{If } Q_M = Q_U \tag{7}$$

Priority P is the ratio of the queue size of multicast which is the number of multicast packets, and the queue size of unicast which is the number of unicast packets. When both queue size is equal, $Q_M = Q_U$, P results one which means each queue gets the same chance(same time interval) to transmit packet in each round because both multicast and unicast queue have the same queuing delay. In this case, the system uses SBRR to be fairness between queues. Otherwise, when the queue size of multicast and unicast are not equal, $Q_M \neq Q_U$, P results greater than or less than one which means each queue gets the more chance(different time interval) to transmit packet in each round. In meanwhile, in order to balance queuing delay and fair resource distribution between two services, the proposed scheduler utilizes SBPRR which is the property of RR with priority of the queue [11].

The priority of the multicast and unicast changes adaptively to balance between these services depending on both queue sizes. When queue size of multicast increases, the multicast priority will increase. When the queue size of unicast increases, the multicast priority will decrease. The service based scheduling algorithm with priority and without priority is as shown in Fig 2.

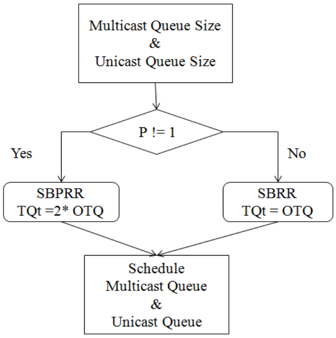

Fig. 2. Service based Scheduling algorithm

To achieve the fairness between the multicast and unicast stream in WLAN, in the same case of queue size, i.e, (P = 1), the system uses SBRR which gives the same time quantum (TQt) at time t as an original time quantum (OTQ) for both queues in round robin manner. Otherwise, the system will use SBPRR to schedule each queue within calculated TQ according to queue priority not to be much queuing delay, which will double OTQ according to the greater priority value of each queue and other will get OTQ. In our experiments, we use NS3 Simulation to test proposed algorithms for four traffic types of 10 mobile users in an AP in WLAN, and compare RT delay fairness and NRT throughput fairness using Jain's fairness index for users who use mixed multicast services as described in Fig 3. Fig 4 shows for users who use mixed unicast services according to their queue size. We observe that overall fairness of the system increases and stable for all users as the queue size increases which it means increasing mixed traffic in WiFi can cause high packet loss rate and long delay for users.

4 Second Stage Scheduling for Real Time and Non Real Time Traffic

The system schedules the multicast or unicast queue as first step scheduling as explained above and then implements the compound scheduling method for fairness of mixed traffic of mobile users by multiplying the corresponded priority value with PF for NRT traffic and DT for RT traffic respectively. It calculates priority value for RT and NRT traffic according to Bayesian Scheme with Two Priority Classes and

Proportional Priority Distribution [12]. The paper proposes a method for proportional priority calculation of mixed traffic types of each mobile user to get fair priority probability value in getting traffic scheduling time interval of second stage scheduling. The system introduces combined scheduling matrix such as PF for NRT traffic and DT for RT trpaffic described in (13) and (14) by using the priority calculation for each traffic type as in (8) to (12).

Therefore, it pays attention on PF for first part of equation which tries to increase the degree of fairness among connections by selecting those with the largest relative channel quality between the connection's current supportable data rate and its average throughput [13]. In second part of equation, It also uses the popular delay related scheduling metric [13] will be implemented with threadshold value not to be bound threadshold delay for RT. Then, it schedules both RT and NRT traffic according to P_{rt} and P_{nrt} in each associated time interval as in (13) and (14). Equation (13) is for unicast traffic and (14) is for multicast traffic to satisfy a user with least channel condition in multicast group. The compound scheduling is determined to be summation of individual policies by multiplying each police with associated real priority P_{rt} for first policy and non real priority P_{nrt} for the second policy [13]. As shown in Fig 5 and Fig 6, we compare throughput and delay between priority value of our proposed system and proposed priority value (0.3 and 0.7 for NRT and RT) described in [13] to get fairly maximum throughput and minimum delay for ten mixed traffic at an AP in WLAN.

$$\alpha_{nrt} = \frac{Q_{nrt}}{Q_M} \tag{8}$$

$$\alpha_{nrt} = \frac{Q_{nrt}}{Q_U} \tag{9}$$

$$P_{rt} + P_{nrt} = 1 \tag{10}$$

$$P_{rt} = \min\left(1, \left(1 + \alpha_{nrt}\right) * \rho\right) \tag{11}$$

$$P_{nrt} = 1 - P_{rt} \tag{12}$$

$$j = \max\arg_{\substack{1 \le k \le K \\ 0 \le j \le 1}} \left\{ P_{nrt}(D_{k,j}(t) / R_{k,j}(t)) + P_{rt}(d_{k,j} / d^{th}_{k,j} - d^{av}{}_{k,j}) \right\} \tag{13}$$

$$j = \min\arg_{\substack{1 \le k \le K \\ 0 \le j \le 1}} \left\{ P_{nrt}(D_{k,j}(t) / R_{k,j}(t)) + P_{rt}(d_{k,j} / d^{th}_{k,j} - d^{av}{}_{k,j}) \right\} \tag{14}$$

Where, $\arg\max$ denotes the argument of maximum, k is the index of user and K is the total number of user, $j = 0$ represents RT stream and $j = 1$ represents NRT stream. For NRT, $D_{k,j}(t)$ represents the instantaneous data rate that can be achieved by j stream of user k at time t and $R_{k,j}(t)$ represents the average data rate that j stream of user k perceived at time t. In RT, $d_{k,j}$ is the delay encountered by a packet at the head of the j^{th} stream of the k^{th} user. $d^{th}_{k,j}$ represents the delay threshold for packets at the j^{th} stream of the k^{th} user. $d^{av}{}_{k,j}$ represents the average delay for packets at j^{th} stream of the k^{th} user.

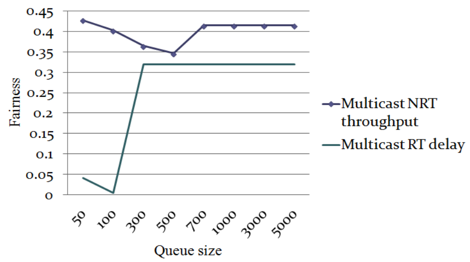

Fig. 3. Fairness between RT delay and NRT throughput for multicast users

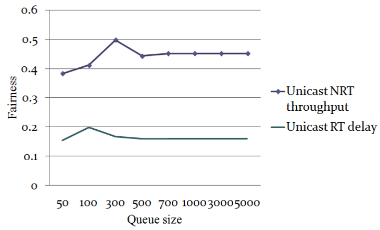

Fig. 4. Fairness between RT delay and NRT throughput for unicast users

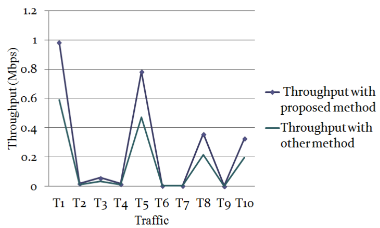

Fig. 5. Throughput between ten mixed RT and NRT traffic

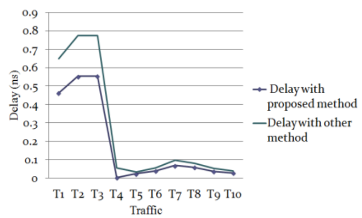

Fig. 6. Delay between ten mixed RT and NRT traffic

5 Conclusions

The paper proposes the framework of traffic management and packet scheduling to increase bandwidth usage and fairness without much delay for mobile users in WLAN and solve mixed traffic problem for four different traffic types and priority issue for them. The scheme has more performance in mixed applications in WLAN with a high degree of compatibility with existing scheduling methods. It can be applied not only WLANs but also other wireless and mobile networks. As a future work, we will investigate and implement the framework to be satisfied with QoS parameters with real wireless environment, many multicast groups and consider congestion avoidance for mobile traffic.

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