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Effective Congestion Control and Scheduling for Wireless Network Using Prioritized Queuing Mechanism

R.Keerthana PG Scholar, Dept. of CSE, Sona College of Technology, salem – 636005, TN, India

S.Lavanya Asst. Professor, Dept. of CSE, Sona College of Technology, – 636005, TN, India

ABSTRACT

The application of sliding mode control in wireless network is used for considering the joint congestion control and scheduling which can be decomposed by dual decomposition method and are considered separately. The lagrangian price enables the communication among these two sub problems. Therefore the sliding mode control is used to control this value for effective congestion control and scheduling. Furthermore, the queuing structure is proposed which combines CBWFQ and strict PQ (packets are classified into different classes and priorities are given to these classes) where the higher priority are given to delay sensitive packets and are scheduled effectively.

KEYWORDS :

1. Introduction

Some applications like VOIP requires minimum rate to obtain end-to end quality. In such situation, a network should be designed in a manner to obtain high quality of service for which the rate or congestion control has to be considered. The congestion occurs in three situations: a) Queuing delay, b) Packet loss, c) Decrease in date rate. Firstly, the queuing delay of the data packets increases. Once there occurs the delay then that would lead to the loss of packets and, due to which the lost packets needs to be retransmitted. Hence the traffic is dominated by retransmissions, so the data rate decreases. Delay, loss and single-bit or multi-bit explicit signals from routers can be used as feedback for congestion control. The congestion control is to control the rate at which the various traffic sources inject the traffic into the network. Control theory shows good ways to solve this problem. The control can be considered in two aspects .

Per-destination queue and per-link queue are the two queuing structures that are generally used. In per-link queuing structure the number of queues used is greatly reduced than the number of queues in per-destination queuing structure. In per-link queuing, the number of queues is based on the number of links connected with a node (number of nodes in the next-hop).

2. System Model

2.1 Joint Congestion Control and Scheduling:

Traditionally, network protocols take a strictly layered structure and implement congestion control, routing and scheduling independently at different layers. However, wireless spectrum is a scarce resource, and it is important to use the wireless channel efficiently. In order to achieve high end-to-end throughput and efficient resource utilization, congestion control, routing and scheduling should be jointly designed while the architectural separation among them is preserved .

The need for joint design across these three layers is motivated by three observations. First, wireless channel is a shared medium and interference-limited. Unlike in wire-line networks where links are disjoint resources with fixed capacities, in ad hoc wireless networks the link capacities are "elastic" and the contention among links provide a fundamental constraint for resource allocation i.e., they determine the feasible rate region at link layer [13].

Second, most routing schemes for ad hoc networks select paths that minimize hop count. This implicitly predefines a route for any source-destination pair of a static network, independent of the pattern of traffic demand and interference/contention among links. This may result in congestion at some region while other regions are under-utilized. To use the wireless spectrum more efficiently, we should exploit multiple paths based on the pattern of traffic demand and interference/contention among links. As we will see below, routing is then determined from the rate and scheduling constraints. Lastly, TCP congestion control algorithms can be interpreted as distributed primal-dual algorithms over the Internet to maximize aggregate utility. This series of work implicitly assumes a network where link capacities are fixed and routes are pre-specified. Here, we extend the basic utility maximization formulation with rate constraints at nodes and additional constraints on scheduling at link layer.

2.2 Network Utility Maximization:

The joint congestion control and scheduling in wireless networks is challenging due to unreliability, time varying channel and interference among wireless channels. Therefore the Network Utility maximization (NUM) problem can be used to formulate the joint congestion control and scheduling [2].

We now consider the analog of the resource allocation problem in a communication network such as the Internet. Suppose we have a network with a set of traffic sources S and a set of links L. Each link l ∈ L has a finite fixed capacity. Each source in S is associated with a route r c L along which it transmits at some rate. Note that we can use the index r to indicate both a route and the source that sends traffic along that route and we will follow this notation. Also since multiple sources could use the same set of links as their routes, there could be multiple indices r which denotes the same subset of L. The utility that the source obtains from transmitting data on route r at rate is denoted by () [2],[4],[14].

$$max\ \Sigma U^s(x^s)$$

Such that,

$$h \leq 0$$

$$x_{i,j} - F^0_{i,j} + F^i_{i,j}$$

$$x^s = \sum_{i \epsilon b^s} \sum_{j \epsilon N} x^s_{i,j}$$

The joint congestion control and scheduling representation using NUM problem [2],[14] can be given as,

$$max\ \Sigma U^s(x^s) - \Sigma_{i,j\,\epsilon\,L} \lambda_{i,j}(\ x_{i,j} - F^0_{i,j} + F^i_{i,j})$$

2.3 Dual Decomposition:

From the NUM problem the congestion problem and scheduling problem can be decomposed separately as follows

$$\max\left(\Sigma U^{s}(x^{s}) - \sum_{i,j \in L} \lambda_{i,j}(x_{i,j}) + \max \sum_{i,j \in L} \lambda_{i,j}(F_{i,j}^{0} - F_{i,j}^{i})\right.$$

2.4 Sliding Mode Based Control:

A sliding surface is constructed for switching surfaces so that the system restricted to the switching surface produces a desired behavior. For convenience only linear switching surfaces of the form (t) = 0 are considered in practice.

For sliding mode controller switched feedback gains which drive the state trajectory to the sliding surface and maintain it there. For the existence of a sliding mode on the switching surface, the state velocity vectors should be directed towards the surface, i.e., the system must be stable to the switching surface. Therefore a Lyapunov function can be used for maintaining the stability.

The behavior of the system on the sliding surface is given as

$$L(x,\lambda,v) = f(x) + \sum_i \lambda_i f_i(x) + \sum_j v_j h_j(x)$$

Where, is Lagrangian price [1], this lagrangian price can be updated according to

$$\lambda_{i,j}(t) = [y_{i,j}(X,t)(x_{i,j} - F_{i,j}^{0} + F_{i,j}^{i})] \quad \forall i,j \in L$$

This lagrangian price value is proportional to the queuing length (or) delay in the node [1].

Each of the input flow and output flow is obtained by estimating some parameters like arrival rate, transmission rate, and receive rate. The sliding mode controller is designed to adjust these parameters for stable behavior of the system, which in turn provide the feedback to control the delay value by maintaining the flow rate to a stable value by which congestion can be controlled [1].

Since the scheduling problem is given as

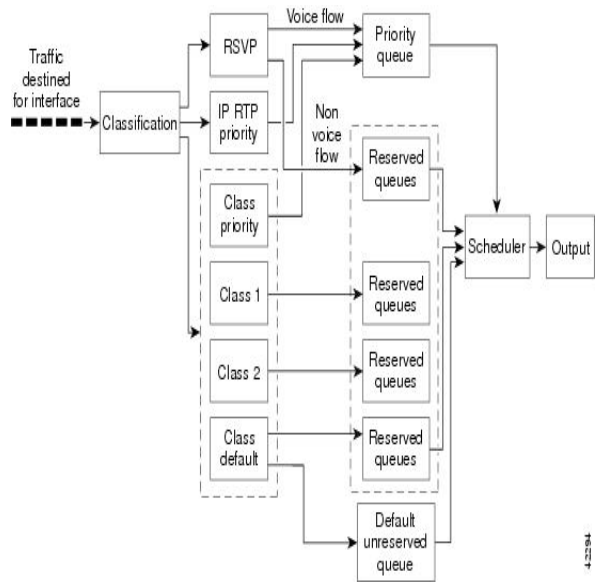
$$\sum_{i,j \in L} \lambda_{i,j}(t)(F_{i,j}^{0}(t) - F_{i,j}^{i}(t))$$

It is seen that the scheduling also depends in some way on value. Hence by changing this value the packets would be scheduled properly.

3. Proposed System

The proposed queuing structure combines the feature of strict PQ (Priority Queue) and CBWFQ (Class Based Weighted Fair Queue). CBWFQ provides WFQ based on defined classes with no strict priority queue available for real-time traffic. CBWFQ allows you to define traffic classes and then assign characteristics to that class. For example, you can designate the minimum bandwidth delivered to the class during congestion [16].

For CBWFQ, the weight for a packet belonging to a specific class is derived from the bandwidth you assigned to the class when you configured it. Therefore, the bandwidth assigned to the packets of a class determines the order in which packets are sent. All packets are serviced fairly based on weight; no class of packets may be granted strict priority.



Strict PQ allows delay-sensitive data such as voice to be de-queued and sent before packets in other queues are de-queued.

Thus by the proposed queuing structure the delay can be reduced and the delay sensitive applications can be supported.

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