ISSN:0975-9646

Shiji.S et al, / (IJCSIT) International Journal of Computer Science and Information Technologies, Vol. 5 (3) , 2014, 3005-3010

Bandwidth and Transmit Power Allocation for QoS Support in Wireless Networks

Shiji.S, S.Subasree

Department of Computer Science and Engineering
Nehru College of Engineering and Research Centre
Pampady, Thrissur.

***Abstract*— With the continued increase of speed and capacities of computing devices and the growing needs of people for mobile computing capabilities, allocation of resource plays a vital role in research community. Quality of service (QoS) provisioning in MANETs is an essential component needed to support multimedia and real-time applications. Maximizing the utility of the traffic flow is a challenging problem. To overcome this problem a new framework was designed. This framework achieves the maximum utility of the flow by considering Channels, Transmission power levels and Bandwidth as the parameter. The framework uses two methods. One is cross decomposition approach to overcome the problem due to self-interference of the packets. We build admission control along with this method which avoids congestion in network by only admitting requests which do not cause self interference. This cross decomposition approach compared with Utility based allocation to find the optimal solution. This algorithms act as designing guidelines for resource allocation of QoS traffic in a wireless network, which take into account the total available resource of network, the users' traffic characteristics, and the users' channel qualities. This work focuses the resource allocation in terms of Channels, Transmission power and bandwidth. A comparison between both the methods is also performed.**

***Keywords*— Wireless Network, QoS, MANET, Resource Allocation, Utility Maximization, Bandwidth allocation**

I. INTRODUCTION

Recently there has a surge of interest in designing a wireless network providing Quality of Service (QoS) by considering delay, jitter, packet loss, throughput etc. For real time applications such as voice and video conferencing, a minimum rate requirement has to be met in order to ensure adequate end-to-end quality. With the increase of speed and capacities of mobile and wireless devices and the growing needs of people for mobile computing capabilities also increases. Resource allocation plays a very vital role in research community. Quality of Services (QoS) in Mobile Ad-Hoc Networks (MANET'S) which is universally growing area. A mobile Ad hoc network (MANET) is an autonomous system of mobile routers connected by wireless links. Ad hoc wireless networks are self-creating, self organizing, and self-administrating networks. Hence, they offer exclusive benefits and flexibility for a variety of situations and applications. Because of these features, the Ad hoc networks are used where wired network and mobile access is either blocked or not feasible. The need for resource allocation is vey important in wireless networks, as the requirement of each source varies for different application. In telecommunication networks, QoS refers to several related aspects that allow the transport of traffic with special requirements. In order to guarantee the QoS in future wireless networks, it is desirable to implement certain resource allocation design mechanism to allocate the limited resource such as bandwidth, channel, and transmit power etc among all the users fairly and efficiently. A framework for maximizing the aggregate utility of traffic sources while adhering to the capacity constraints of each link and the minimum rate requirements imposed by each of the sources was designed[1],[2]. The framework takes into account the self-interference of flows and assigns channels, and time slots to each link such that the above objective is achieved. More importantly, the QoS needs to be provided under conditions of self-interference, where the packets of a flow interfere with other packets that belong to the same flow along a multi-hop path. The utility optimization model has been widely adopted in the research of end-to-end congestion control [14]-[17] by viewing variant congestion control protocols as distributed algorithms to solve some basic network utility maximization problems. The degree of user satisfaction can be described by the utility function of the traffic type under consideration. Utility-based allocation schemes in wireless networks are proposed in [11], [12]. Kuo and Liao [13] studied the issue of resource allocation for two types of traffic, that is, best effort and hard QoS traffic. Our approach establishes that in a wireless network, the base station can optimally allocate the resource among the competing soft QoS traffic to maximize the total utility of all users. We consider self-interference in wireless networks and a method was designed to overcome it. The proposed framework act as designing guidelines for resource allocation of soft QoS traffic in a wireless network, which take into account the total available resource of network, the users' traffic characteristics, and the users' channel qualities.

The remainder of the paper is organized as follows. Related work is described in brief in Section II. Problem description is given in section III. Section IV describes the Quality of Service. Cross layer decomposition framework is given in Section V and Section VI describes about utility based maximization. The Result and discussion is given in Section VII. We conclude the paper in Section VIII.

II. RELATED WORKS

The problem of joint routing, link scheduling and power control to support high data rates for broadband wireless multi-hop networks was studied. It address the problem of finding an optimal link scheduling and power control policy that minimizes the total average transmission power in the wireless multi-hop network, subject to given constraints regarding the minimum average data rate per link, as well as peak transmission power constraints per node. Multi-access signal interference is explicitly modeled. A duality approach is used whereby, as a byproduct of finding the optimal policy, and the sensitivity of the minimal total average power with respect to the average data rate for each link. Since the minimal total average power is a convex function of the required minimum average data rates, shortest path algorithms with the link weights set to the link sensitivities can be used to guide the search for a globally optimum routing. Moreover, they find that optimum allocations do not necessarily route traffic over minimum energy paths. Broadband wireless networks today are capable of supporting high data rates. Minimizing the total power in such systems is of paramount importance not just to increase its own operational lifetime in the case of battery powered devices, but also to coexist symbiotically with other systems which share the same frequency spectrum [3]. An online algorithm was presented for channel assignment, scheduling and routing. This online algorithm does not require prior information on the offered load to the network, and can adapt automatically to the changes in the network topology and offered load. Even compared with the optimal centralized and offline algorithm, the proposed distributed algorithm can achieve a provable fraction of the maximum system capacity [4]. Congestion control with power control has been studied in [10]. Link scheduling with contention control has been looked at in [5]–[7]. Link scheduling with power control was formulated as an optimization problem [8]. Resources management at the lower layers has been considered in [9]. Different types of routing protocols and routing metrics are discussed [18].

III. PROBLEM DESCRIPTION

First we consider the problem of resource allocation with QoS support in terms of providing a minimum data rates to each flow. We also take self-interference under consideration in wireless networks. In other words, the competition among the packets belonging to the same flow that cause congestion and delay in throughput is avoided. Another challenging problem is the utilization of resource in networks. Maximum utilization of resource is needed in order to avoid underutilization of resource. A utility function is defined, which allocates the amount of bandwidth received by the application to the performance as perceived by the user. Utility function is monotonically non-decreasing; the more bandwidth allocation should not lead to degraded application performance. The key advantage of utility function is that it can inherently reflect the QoS requirements of the end user. The exact expression of a utility function may depend on the type of traffic.

IV. QUALITY OF SERVICE

Quality of Service (QoS) is a generic term collectively used to access the usefulness of any system with user's perception. In computer networks, QoS adds mechanisms to control the network activity such as transmission and error rates, to assure certain level of service parameters to the end users. The main goal of QoS provisioning is to achieve more deterministic network behaviour, so that information carried by the network can be delivered guaranteed and network resources are better utilized. The network services can be characterized by a set of parameters such as minimum bandwidth, maximum delay, maximum delay variance (jitter), and maximum packet loss rate etc. After accepting a request from the user, the network has to ensure that service requirements of the users flow are met, as per the agreement throughout the duration of the flow In other words, the network has to provide a set of service guarantees while transporting data through a flow. QoS is necessary in mobile Ad hoc networks because different applications have different service requirements; for example, VoIP considers issues like jitter, delay and minimum bandwidth. While there is a high mobility of users and network nodes, bandwidth and battery capacity are scarce resources, and will be the important consideration for QoS.

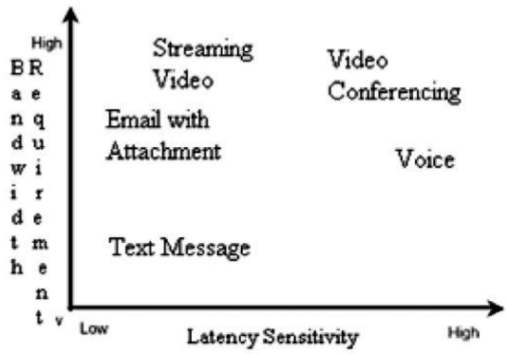

Fig 1: Different Application and Network Requirements

Different Applications require different network performance, based on bandwidth needs and latency sensitivity. The needs of various applications in context to bandwidth and latency sensitivity requirements are shown schematically in Fig 1. It can be observed that higher the latency sensitivity, higher is the bandwidth requirement; Data-transfers tend to have zero tolerances for packet loss and high tolerances for delay and jitter. Typical acceptable response times range from a few seconds for FTP transfers to hours for email. Voice and Video conferencing applications require both high bandwidth and high latency sensitivity.

Traffic behavior and QoS requirement of different applications vary from one to another. In HTML web browsing, the bandwidth requirement varies, since the data is transferred in a series of bursty files. Video/voice streaming tends to have low tolerances for packet loss and medium tolerances for delay and jitter. Typical acceptable response times are in the order of a few seconds, because of the well known fact that the server can pre-buffer multimedia data on the client to a certain degree. This buffer then drains at a constant rate on the client side, while simultaneously, receiving bursty streaming data from the server with variations in delay. The issue of providing different quality of service levels to the user in a constantly changing environment is to achieve a more deterministic network behavior, The objective is that the information carried by the network can be successfully delivered and resources can be better utilized in terms of parameters like end-to-end delay statistics, available bandwidth, and probability of packet loss etc. For obtaining QoS on a MANET, it may not be sufficient to provide a basic routing functionality, other aspects may also be taken into consideration such as, bandwidth constraints due to shared media, dynamic topology, since MNs are mobile and the topology may change and power consumption due to limited batteries. After accepting a service request from the user, the network has to ensure that service requirements of the users flow are met, as per the agreement, throughout the duration of the flow. In other words, the network has to provide a set of service guarantees while transporting a flow. After receiving a service request from the user, the first task is to find a suitable free path from the source to the destination that will have the necessary resources available to meet the QoS requirements of the desired service. This process is known as QoS routing. After finding a suitable path, a resource reservation protocol is employed to reserve necessary resources along that path. When once reservation of resource is made transmission of data will carry out.

V. CROSS DECOMPOSITION APPROACH

Cross Decomposition approach finds the solution for maximum utility function. To solve the maximum utility function scheduling problem is considered. Scheduling problem considers transmit power, channel assignment. Without transmit power no node can transfer data. Channel assignment is also important for the data transmission. While assigning channels, self-interference are considered, which arise due to the overlapping of packets in the same flow. Different from wired links that are having dedicated bandwidth, the bandwidth of a wireless link is shared between neighboring nodes. A flow through wireless links not only consumes the bandwidth of the nodes along its path, it also contends for bandwidth with the nodes that are in the neighboring area of its path. Such inter-flow interference can result in bandwidth starvation for some nodes since these nodes may always experience busy channels. To prevent such starvation, a routing metric must help routing protocols choose paths that can balance not only the traffic load along the path of a flow, but also reduce the inter-flow interference imposed in the entire neighboring area. An example of inter flow interference is shown in Fig 2 the path A–>D–>C Suffered from inter flow interference since node D is shared by neighbor node E. To transmit data form node A to node C the less interference path is A–>B–>C. Cross Decomposition approach adopted a method to avoid self-interference. Initially it finds all the active and de-active links in the networks. Before assigning a channel it check whether the channel is active or de-active. The channel is selected for allocation only if the channel is in non-active state and also a particular channel is active only if its residing nodes are having certain amount of transmit power required for the transmission of data which must be greater than zero. The node is selected for flow by checking all the incident links on it. If any of the links are active then that node is omitted for the new transmission.

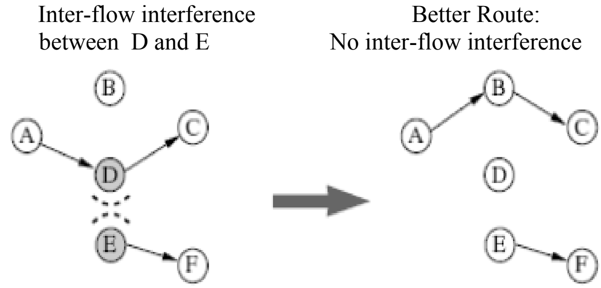

Fig 2. An Example for inter flow interference

We are assuming the capacity on each links as constant. The data rate on each link should be greater than zero and less than the maximum capacity on that link. And we also assume that there should at least one link present in between a pair of nodes. Each node is allocated certain amount of transmit power. According to the QoS requirements of applications the user can request more or less amount of transmission power for each node. The power will be allocated by the system only if the node can accommodate that power. As a system model we are considering ten nodes and a link is presented in between each pair of nodes. The capacity of each node is assumed to be constant. Initially each node is allocated a certain amount of transmit power.

A. *Channel Assignment*

The proposed algorithm allocates channels in a way such that self-interference is avoided. The links with higher transmit power are assigned higher priorities in terms of channel assignment over the links with lower power. This is because, links with higher power suffer from higher levels of congestion and thus, scheduling these links is harder. The proposed channel assignment algorithm starts by sorting links in the descending order of their power. Then, channels are assigned to the links in that order. The proposed algorithm avoids self-interference by not assigning a channel to any link whose incident links have already been assigned to any of the channels. In other words, a link is eligible for activation only if it has no active neighbor links. In order to alleviate the effects of co-channel interference, the channel that is assigned to a link is selected based on the sum of link gains between all the interfering senders using the same channel and the receiver of the link. The proposed channel assignment is summarized in Algorithm 1

Algorithm 1 Channel Assignment

1: Sort all links by descending order of their transmission Power.
2: Choose a link for transmission on the basis of the QoS requirement of user
3: Check whether there is any active incident link on the

nodes in the selected path
4: If there is active incident link then avoid selected path
5: Choose another path for transmission
6: Goto step 2

B. *Admission Control*

Our approach is extended to support admission control in order to avoid congestion in network. Admission control is usually performed by dropping a new request which may cause throughput degradation. Here the admission control is performed for the avoidance of interflow interference which may arise due to admission of new request to the network. Admission control approach is summarized in Algorithm 2 given below.

Algorithm 2 Admission Control

1: Initialize E–>0, F–>0
2: Put the existing active links in E
3: Put the de-active links in F
4: If the user requested paths are in E
5: Reject or Drop the request
6: Else if the requested path is in F
7: Admit request

VI. UTILITY BASED MAXIMIZATION

In the utility based allocation (UBA) scheme we allocate bandwidth as a resource for the competing soft QoS traffic. We considered the total available resources as R in base station as constant. Bandwidth is allocated to each flow and quality of channel is considered for each flow which is the ratio of resources received by the resources allocated to each flow. Let U(r) be the utility function which is defined as the utility of resources by each flow. The U(r) can be calculated as the product of bandwidth of flow and channel quality. The utilization domain is [0,R] and will be different for different flow. The utility of resources also depends on the channels assigned for each flow.

For the users with QoS traffic, the utility function should be a monotonically increasing function. Since the QoS requirement needs to be satisfied, when the resource obtained by the user is less than the requested value for the QoS requirement, the priority of the request for the resource of this user is strong, and the marginal utility function is monotonically increasing. When the resource obtained by the user is more than the requested value for the QoS requirement, the priority of the request for the resource of this user is low, which prevents assigning surplus resource to some certain users, and the marginal utility function is monotonically decreasing. In summary, the utility function for QoS users should be a sigmoid function with respect to the allocated resource. For the users with QoS traffic, the resource requirement is r_0, then we can get the characteristics of the utility function

$$0 < r < r_0, (r) > 0, u'(r) > 0 \qquad (1)$$

$$r_0 \le r < R, (r) > 0, u'(r) \le 0 \qquad (2)$$

$$U(0) \approx 0, U(R) \approx 1$$

Where $u'(r)$ is the first derivative of $u(r)$. According to the conditions (1) (2), we get the utility function for QoS users as

$$U_1(r) = \frac{1}{1+e^{-c1(r-r0)}} \qquad (3)$$

where the parameter c_1 is used to adjust the slope of the utility curve around r_0 and is assumed to be constant. It reflects the demand degree of the user for the resource requirement r_0. The larger c_1 is, the higher the slope of the utility curve around r_0 is, so that the user demands the resource r_0 more strongly, or on the contrary, the demand is weaker.

Algorithm3: Utility Based Allocation Algorithm for QoS user

1: User make requeat r_0 to base station
2: Base station allocate resource r to the user
3: If $r < r_0$
4: Then calculate utility function by equ (3) and is monotonically increasing
5: Else $r>r_0$
6: Calculate utility function by equ (3) and is monotonically decreasing
7: end if

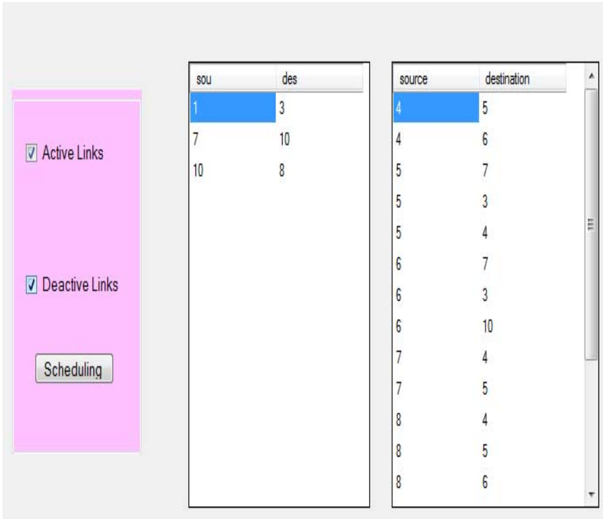

Fig 3: Current Active and De-active links in Network

VII. RESULTS AND DISCUSSIONS

The implementation part consists of mainly two parts. The experimental results are shown in the figures given below. C# dot net framework is used as a front end for the implementation. One part of the implementation is the cross decomposition and the second is the utility based allocation. In the cross decomposition method active and de-active links are found to avoid self-interference as shown in Fig 3. By finding active and de-active links before assigning channels, QoS in the network can be maintained. Then channels are assigned for the transmission of data on the basis of transmission power. The total time taken for the transmission of data and the net resources used for the transmission is calculated. In the utility allocation scheme bandwidth is considered as the resource for the utility maximization. Certain bandwidth is allocated to each flow and each flow is assigned a channel quality. Utilization of resources based on the bandwidth and channel quality is calculated along with the time taken for the data transmission. The following graphs show the results of the implementation of both methods.

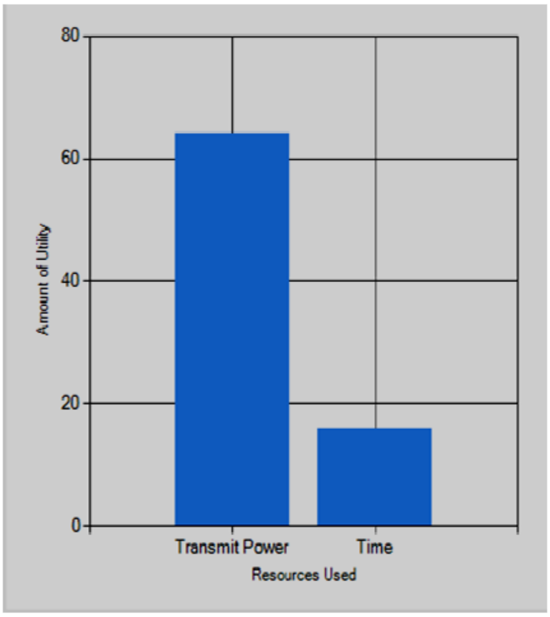

Fig 4: Cross Decomposition Method

The utilization of resources by the cross decomposition method is given in Fig 4. X axis consists of two parameter time and resources; this is the total amount of time taken for sending data and the total utilization of resources by a particular flow 'i' for the transmission. The resources considered here is transmit power. The utilization of resource will be different for different flow according to transmission power selected for the flow and time varies accordingly.

The resources utilized by the utilization based allocation scheme shown in the graph given in Fig 5.It shows the total time taken to transmit data through the selected flow and also the total amount of resources utilized by that flow. The resource considered here is the bandwidth. The utilization will varies for different flow based on the amount of bandwidth and the channel quality requested by the user.

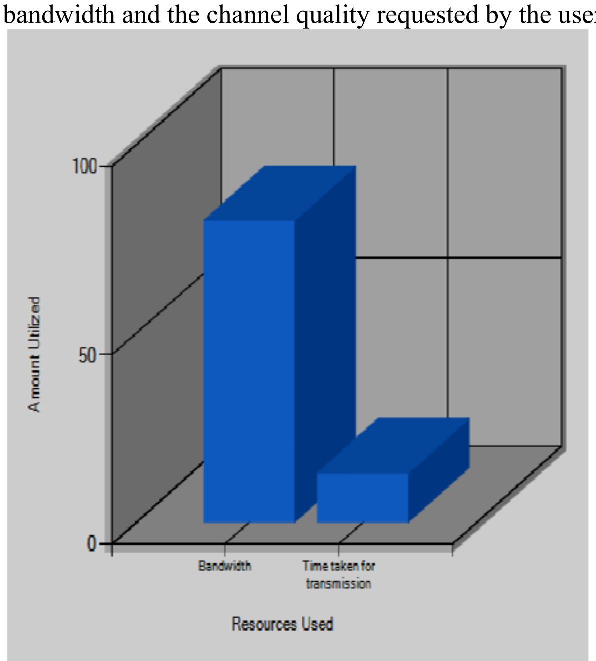

Fig 5: Utility Based Maximization Method

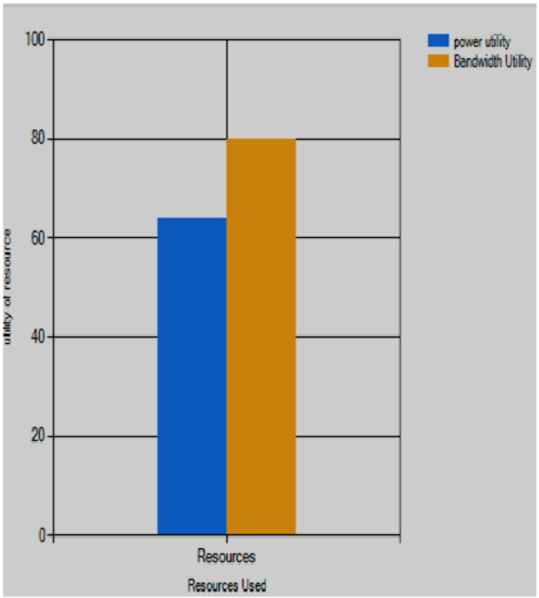

Fig 6: Comparison of the utilization of resource

A. Comparison

In the comparison part we are comparing the utilization of both methods and the time taken for the transmission of data is also plotted. The Fig 6 shows the analysis of the utilization of transmit power and bandwidth. It shows that the utilization of bandwidth is highest as compared to transmit power. Fig 7 shows the analysis of time taken for the transmission of data by allocating transmits power and bandwidth as the resource.

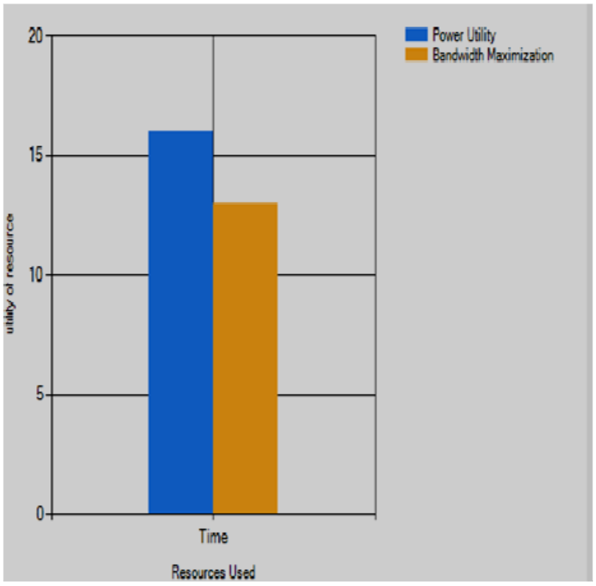

Fig 7: Comparison of time taken for transmission

VIII. CONCLUSION

In this paper, we develop a resource allocation framework for wireless mesh networks. The framework maximizes the aggregate utility of flows taking into account constraints that arise due to self-interference (wireless channel imposed constraints) and minimum rate requirements of sources (QoS requirements). Cross decomposition method intelligently avoids self-interference. The proposed methods leads to a simply and effective admission control mechanism. Another method utility based allocation is also designed which calculates the utility of flow based on bandwidth and channel quality. Comparison of utilization of resource is performed.

REFERENCES

[1] T. Kim, Y. Yang, J. Hou, and S. Krishnamurthy, "Joint resource allocation and admission control in wireless mesh networks," in *2009 WiOpt*.

[2] T. Kim, Y. Yang, J. Hou, and S. Krishnamurthy, "Resource allocation for QoS support in wireless mesh networks," in *2013 IEEE Transactions.*

[3] R. Cruz and A. Santhanam, "Optimal routing, link scheduling and power control in multi-hop wireless networks," in *2003 IEEE INFOCOM*.

[4] X. Lin and S. Rasool, "A distributed joint channel-assignment, scheduling and routing algorithm for multi-channel ad hoc wireless networks," in *2007 IEEE INFOCOM*.

[5] J. Lee, M. Chiang, and R. Calderbank, "Jointly optimal congestion and contention control in wireless ad hoc networks," *IEEE Commun. Lett.*, vol. 10, no. 3, pp. 216–218, 2006.

[6] J. Zhang and D. Zheng, "A stochastic primal-dual algorithm for joint flow control and MAC design in multi-hop wireless networks," in *2006 CISS*.

[7] L. Bui, A. Eryilmaz, R. Srikant, and X. Wu, "Joint congestion control and distributed scheduling in multihop wireless networks with a node exclusive interference model," in *2006 IEEE INFOCOM*.

[8] P. Soldati, B. Johansson, and M. Johansson, "Proportionally fair allocation of end-to-end bandwidth in STDMA wireless networks," in *2006 ACM MobiHoc*.

[9] M. Neely, E. Modiano, and C. Rohrs, "Dynamic power allocation and routing for time varying wireless networks," in *2003 IEEE INFOCOM*.

[10] M. Chiang, "Balancing transport and physical layer in multihop wireless networks: jointly optimal congestion and power control," *IEEE J. Sel. Areas Commun.*, vol. 23, no. 1, pp. 104–116, 2005.

[11] Bianchi G, Campbell AT. A programmable MAC framework for utility-based adaptive quality of service support.*IEEE Journal on Selected Areas in Communications* 2000; **18**(2):244–255.

[12] Wu KD, Liao W. Flow allocation in multi-hop wireless networks: a cross-layer approach. *IEEE Transactions on Wireless Communications* Jan. 2008; **7**(1):269–276.

[13] Kuo WH, Liao W. Utility-based resource allocation in wireless networks. *IEEE Transactions on Wireless Communications* Oct. 2007; **6**(10):3600–3606.

[14] Gibbens RJ, Kelly FP. Resource pricing and the evolution of congestion control. *Automatica* 1999; 35(12): 1969–1985.

[15] Kelly FP. Charging and rate control for elastic traffic. *European Transactions on Telecommunications* 1997; **8**(1):33–37.

[16] Kelly F, Mauloo A, Tan D. Rate control for communication networks: shadow prices, proportional fairness and stability. *Journal of the Operational Research Society* 1998; 49(3):237–252.

[17] Low SH. A duality model of TCP and queue management algorithms. *IEEE/ACM Transactions on Networking* 2003; 11(4):525–536.

[18] Y. Yang, J. Wang, and R. Kravets, "Designing routing metrics for meshvnetworks," in *2005 IEEE WiMesh*.