ISSN: 2321-7782 (Online)
Volume 2, Issue 12, December 2014
International Journal of Advance Research in Computer Science and Management Studies
Research Article / Survey Paper / Case Study
Available online at: www.ijarcsms.com

Resource Allocation and Channel Assignment Efficient Algorithms used for QOS Support in WMN

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***Abstract:** Many next generation applications (such as video flows) are likely to have associated minimum data rate requirements in order to ensure satisfactory quality as perceived by end-users. We develop 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. The framework takes into account the self-interference of flows and assigns and minimum rate requirement. the parameters that are tuned in order to maximize the utility are (a) channels (b) transmission power levels and (c) time slots to each link such that the above objective is achieved. It dictates the rates at which each traffic source will send packets such that the minimum rate requirements of all coexisting flows are met. If the minimum rate requirements of all the flows cannot be met, the framework selectively drops a few of the sources and redistributes the resources among the others in a way that their QoS requirements are met in other words the framework rejects a subset of flows (based on fairness considerations) and recomputes the schedule and allocates resources to each of the remaining flow.*

***Keyword:** Wireless mesh network, QoS, congestion control, resource allocation, admission control.*

I. INTRODUCTION

FOR many applications such as video, a minimum rate requirement has to be met in order to ensure satisfactory end-to-end quality [1]. In a shared wireless mesh network, ensuring that application demands are met requires the fol-lowing inter-dependent functionalities: (a) rate or congestion control: control the rates at which the various traffic sources sharing the network inject traffic and (b) resource allocation: allocate resources to the different connections such that the minimum rate requirements of each connection are met and (c) admission control: ensure that newly admitted connections do not cause a violation of the minimum rate requirements of existing flows. Our goal in this work is to design a framework towards jointly facilitating these functionalities. The problem of resource allocation and congestion control in wired networks has received a lot of attention. In their sem-inal work, Kelly et al. [2] have modeled the problem of flow control as an optimization problem where the objective is to maximize the aggregate utility of elastic traffic sources subject to capacity constraints on the links that compose the network. Inspired by Kelly's work, there has been follow up work [3]–[5], where TCP congestion control is modeled a convex optimization problem, the objective being the maximization of an aggregate user utility; in these efforts distributed primal-dual solutions to the problem are proposed. There have been more recent efforts on extending the above congestion control framework to wireless networks .the examples include the work in [6]–[9] and [10]–[13]. In contrast with wireline networks, the capacity of a wireless link is not dependent on other flows in the network but on other flows that use links on the same channel (and that are close enough) and external interference. The dependencies between flows is regulated by the protocols at both the link and transport layers. However, these prior efforts do not consider the provision of quality-of-service in terms of supporting minimum rates to the flows that share the network. 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. Our framework addresses the above two important factors.In more detail, we propose 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. The framework takes into account the self-interference of flows and assigns (a) channels (b) transmission power levels and (c) time slots to each link such that the above objective is achieved. It dictates the rates at which each traffic source will send packets such that the minimum rate requirements of all coexisting flows are met. If the minimum rate requirements of all the flows cannot be met, the framework rejects a subset of flows (based on fairness considerations) and recomputes the schedule and allocates resources to each of the remaining flows.

II. Related Work

Wherever Times is specified, Times Roman or Times New Roman may be used. If neither is available on your word processor, please In [2], Kelly et al., model flow control in a wireline network as an optimization problem. Recently, there has been a lot of research activity on extending the above congestion control framework to wireless networks. In contrast to a wireline link, the capacity of a link in wireless networks is not fixed. As discussed earlier, it depends on the interference due to other flows, which in turn is wireless networks. In contrast to a wireline link, the capacity of a link in wireless networks is not fixed. As discussed earlier, it depends on the interference due to other flows, which in turn is regulated by protocols at various layers. Thus, congestion control in wireless networks has cross layer dependencies. Using mathematical decomposition techniques the cross-layer optimization problem of congestion control can be decomposed into two sub-problems: the rate control problem to be solved at transport layer and the scheduling problem at the lower link layer; the latter is tightly related to the underlying resources to be managed. There have been various approaches that have been proposed for the two layers independently. In particular, congestion control with power control has been studied in [14]. Link scheduling with contention control has been looked at in [6]–[9]. [15] considers the joint impact of link scheduling and routing. Soldati et al., formulate link scheduling with power control as an opti-mization problem . Channel assignment, routing, and link scheduling has been considered while link scheduling, routing and power control are considered in [18]. Resources management at the lower layers has been considered in [10]– [13]. Design of scheduling algorithms and their performance evaluation. None of the above efforts however, consider the problem of resource allocation with QoS support in terms of providing a minimum data rate to flows, in the presence of self-interference in mesh networks. In other words, they ignore the constraints that arise due to competition among the packets belonging to the same flow that spans multiple wireless hops. This effect is taken into account in our work. Finally, to the best of our knowledge, we are the first to propose an admission control policy for ensuring that existing flows get their minimum desired rates and noise ratio (SINR Signal To Interference And Noise Ratio) should be no less than a threshold β 2. In addition, it is assumed that the network operates in a time-slotted mode; time is divided into slots of equal duration. The network has S elastic traffic sources and each source s has an associated data rate rs. We assume that each source s requires at the very least, a data rate rsreq in order to satisfy its QoS requirement. Furthermore, the data rate that may be provided to s is assumed to be upper bounded by rsmax; this corresponds to the peak sending rate of source s, and depends on the application requirements at s. For example, the maximum sending rate of a real-time application can be expected to be much lower than that of an elastic application. the latter can greedily consume any available bandwidth. Each source s has an associated utility function Us(rs); the utility is assumed to directly reflect the QoS provided to source s when it is injecting packets into the network at a rate rs. We assume the utility function to be positive, continuously differentiable, monotonically increasing and strictly concave over [0, rsmax]. Our objective is then, to find the optimal resource allocation in terms of assigning channels, transmit powers, and time slots so as to maximize the sum of the sources' utilities; at the same time, their QoS requirements in terms of minimal rates have to be met. In the rest of the paper, we interchangeably use L (links), C (channels), and S (sources) to denote both the corresponding set itself and the cardinality of the set.

III. WIRELESS MESH NETWORK

A wireless mesh network (WMN) is a communication network made up of combination of wireless nodes organized in a mesh topology. Wireless mesh networks deals with mesh clients, mesh routers and gateways to provide effective resource utilization. The mesh clients are often, cell phones, laptops, and other wireless devices while the mesh routers forward traffic to and from the gateways. The mesh cloud consists of radio nodes communicating with in that cloud transmission area. Radio nodes working in collaboration with each other can access this mesh cloud to create a radio network. A mesh network is always reliable and often offers redundancy. Suppose one of the node can no longer operating, the rest of the nodes can still communicate with each other, directly or through one or more neighbouring nodes. A wireless mesh network (WMN) is a mesh network created through the connection of wireless access points installed at each network user's locale. Each network user is also a provider, forwarding data to the next node. The networking infrastructure is decentralized and simplified because each node need only transmit as far as the next node.

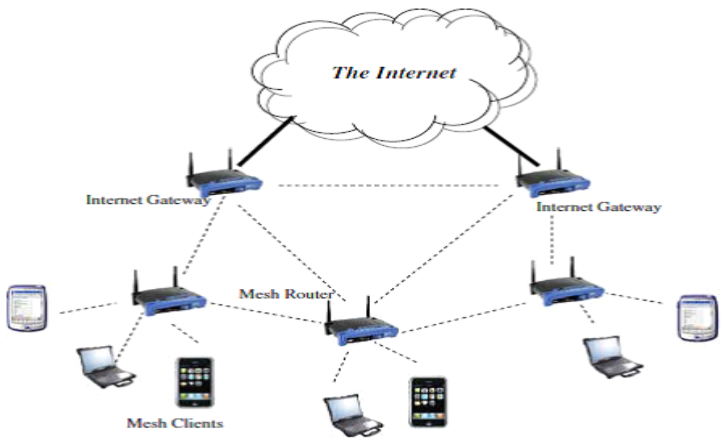

Fig 1. wireless mesh network

IV. CHANNEL ASSIGNMENT

The algorithm allocates channels in a way that (a) self-interference is avoided and (b) co-channel interference levels among links that use the same channel are kept as low as possible. With our algorithm, links with higher costs are assigned higher priorities in terms of channel assignment over the links with lower cost. This is because links with higher costs suffer from higher levels of congestion and thus, scheduling these links is harder.

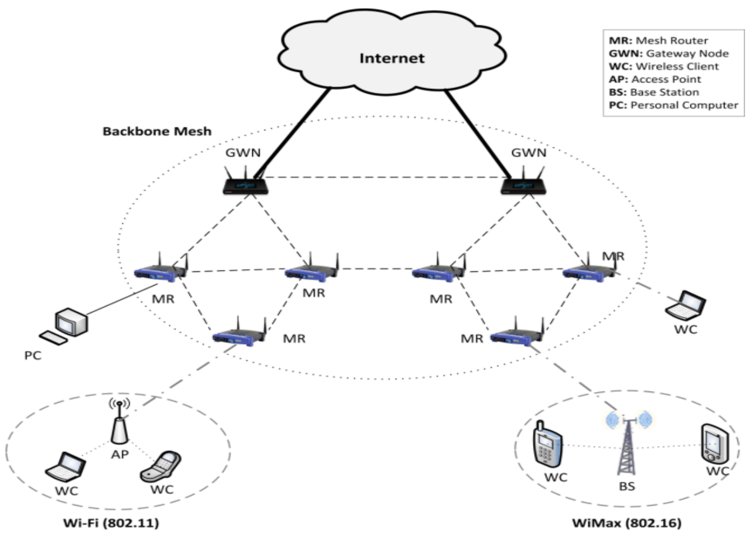

Fig 2. Channel Assignment

The channel assignment algorithm starts by sorting links in the descending order of their link costs. Then, channels are assigned to the links in that order. The algorithm avoids self-interference by not assigning a channel to any link whose incident links have already been assigned 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 cochannel 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. This sum is calculated for each of the channels and the channel with the least associated value is selected for the link.

A. Algorithm 1 channel Assignment

1: Initialization: $x(l,c) \leftarrow 0$, and $Q(c) \leftarrow \emptyset$, $\forall l \in L$ and $\forall c \in C$;

2: Sort links by descending order of λ, and label i-th link in the sorted list as l_i;

3: for $j = 1$ to L do

4: if $\sum_e \sum_c {}^x(e,c) = 0$, for $e \in E(l_j)$ then

5: Calculate $dc = \sum_{q \in Q(c)} g_q l_j$, $\forall c \in C$;

6: Allocate channel $clj = argminc\{d1, d2, . . . , dC\}$ to link l_j ;

7: Assign l_j to $Q(cl_j)$;

8 : end if

9: end for

V. Resource Allocation

The main objective of resource allocation is to allocate resources to the different connections such that the minimum rate requirements of each connection are met. The proposed approach requires both the transport (in terms of end-to-end rate allocation) and the physical layer (in terms of channel and power schedule) to be aligned. Most of the common TCP/AQM(Transmission Control Protocol/ Active Queue Management) variants can be interpreted as distributed methods for solving the optimization network flow problem (determines the end-to-end rates under fixed link capacity). Based on an initial schedule (a simple TDMA(Time Division Multiple Access) link schedule for the first L slots), we run the TCP/AQM scheme until convergence (this may require the schedule to be applied repeatedly). After rate convergence, each node reports the link prices associated with its incoming and outgoing links to gateway where the proposed resource allocation scheme is adopted. On receiving the link prices from the entire set of node, the gateway finds the channels and transmits powers by applying the resource allocation scheme proposed.

A. Algorithm 2 Adaptive Resource Allocation with MG

1: Initialization: $G \leftarrow \emptyset\emptyset, G \leftarrow \emptyset\ \emptyset$

2: Perform Algorithm 1 on the utility maximization problem (8) with $r_s^{req} = 0, \forall s \in S$;

3: Put s into G such that $rs \geq$; r_s^{req} Otherwise, put into G;

4: while $G_ = \emptyset\emptyset$do

5: Remove k from G such that k = $argmax_{\ s} \in G\ (r_s^{req} - rs)$;

6: Solve (8) with $r_s^{req} = 0, \forall s \in GG$;

7: $G \leftarrow \emptyset, G \leftarrow \emptyset\emptyset$

8: Put s into G such that $rs \geq r_s^{req}$; Otherwise, put into G;

9: end

 ISSN: 2321-7782 (Online)

VI. 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). If a solution is not feasible, the framework selectively drops a few of the sources and redistributes the resources among the others in a way that their QoS requirements are met. The proposed framework readily leads to a simple and effective admission control mechanism.

Acknowledgement

The present work is benefited from the input of my research guide Mrs. M.Savitha Devi, Assistant Professor in PG and Research Department of Computer Science, Don Bosco College, Dharmapuri. I would like to thank her, for her valuable assistance to the undertaking of the study report summarized here. And also I would like to thank my management Don Bosco College, Dharmapuri, for giving me this opportunity to present the article.

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