BANDWIDTH ALLOCATION IN WIRELESS MESH NETWORKS

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ABSTRACT

Admission management and channel allocation for end-to-end flows in multi-radio multi-channel wireless mesh networks is provided by interference aware channel allocation approach (IACA). In existing solutions the consequence of inter-flow and intra-flow interference has been neglected, so inaccurate information measure estimation and reservation might occur. The inter-flow interference from existing flows and also the expected intra-flow interference of the incoming flow are taken into account for correct estimation of channel allocation and to perform admission management. Moreover, this approach exploits wireless link diversity in multi-radio multi-channel mesh networks between neighboring nodes within the network thus on improve flow admission quantitative relation and to make sure of load-balancing.

Index Terms—*Multi-radio multi-channel wireless mesh networks, QoS guarantees, Interference, Load-balancing, Interference-Aware channel allocation.*

1.INTRODUCTION

In recent years wireless mesh networks (WMNs) have become a vital player in communication field. The attraction towards WMNs is because of the distinguishable feature it possesses. Autonomous, self-healing and self-configuring are the natures of wireless mesh network. The administrative intervention required is only minimal after setting up the WMNs. The off-the-shelf equipment can be used to build-up the wireless mesh networks. User application requires` QoS guarantees for meeting their needs by the underlying communication infrastructure. However, the wireless medium is shared and unpredictable so, providing QoS in wireless networks is challenging. Moreover, for communication the features of mesh network made them an attractive option, also they have certain challenges which are quite common to them..

Moreover, for mesh nodes in the same geographical region, there is significant inter-flow and intra-flow interference. Due to these factors, over a multi hop end to-end path across the mesh network QoS difficulties may occur. Wireless multi hop networks such as Wireless Sensor Networks (WSNs) and Mobile Ad hoc Networks (MANETs) are already present were as one of the relatively recent advent is wireless mesh networks.

For WSNs and MANETs, QoS solutions have been extensively explored. Solutions proposed for these existing networks influences QoS solutions for mesh networks. However, existing wireless multi-hop networks mesh networks differ significantly in terms of traffic patterns, architecture and user requirements. However, wireless multi-hop networks significantly different from mesh networks in terms of architecture, traffic patterns and user requirements. A literature review of mesh networks QoS solutions shows that QoS solutions for mesh networks are few and mostly focus on providing QoS guarantees in single-radio single-channel mesh networks [1–7]. Only few solutions are defined for multi-radio multi-channel mesh networks [8,9,10].

2.Related works

Few QoS solutions have been proposed for WMNs in which most of the research is towards single-radio single-channel wireless mesh network [1, 2,3,4,5,6,7]. QUORUM, which is a protocol used for routing optimized for WMNs that provides QoS properties by predicting delay and loss characteristics of data traffic [4]. In Channel allocation estimation of bandwidth is done by two methods measurement based approach and model based approach. In which measurement based approach bandwidth allocation will not be more accurate because of using promiscuous listening i.e. for available bandwidth locally decodable packets is used. . Bandwidth estimation is mostly done based on measurement based approach [1, 3, 11, 12].

The works proposed in [13,14] provide stochastic end-to-end delay guarantees by using model-based bandwidth estimation schemes for QoS guarantee in wireless multi-hop networks. Model-based approach is

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used in some hybrid schemes in which measurements are provided as input. A model called conflict graph model is also used for interference free channel allocation in wireless multi-hop networks by identifying groups of mutually interfering links in[5]. However, to estimate the aggregate flow rate on links, Measurement-based approach is used by author to provide input to the model. For multi-radio multichannel mesh networks there are few QoS solutions proposed [8,9,10]. In [8] authors propose that interference from far-off flows near the boundary of the carrier sensing range can also be taken considered for bandwidth estimation. With the on-demand LUNAR routing protocol they integrate bandwidth estimation and admission control But, here significant amount of traffic is generated in this method because here they send probes Periodically to measure the bandwidth of every single link in the network. This may even lead to inaccurate estimation when the network is heavily loaded and the probe packets are lost due to collisions. In [9] a QoS scheme for multi-radio multi-channel mesh networks is proposed by author, in which for channel allocation the Channel Idle Time is used. In [10], a threshold-triggered scheme is proposed for estimating bandwidth in which the residual bandwidth of a path with the consideration of contention on the path is detected by distributed call admission control mechanism. For efficient load distribution none of these above methods exploits the link diversity available in multi-radio multi-channel mesh networks. Moreover, they perform channel measurement at lower layers to estimate the available bandwidth.

In wireless links role of interference in route selection has been focused in number of research works. A number of techniques have been proposed [15,16,17,18,19] to measure interference and to select the minimum interference route. The above techniques are very different from the method used by IACA which attempts to estimate the available bandwidth and does not focus on routing metric for distinguishing links according to the interference present on them. Moreover, these approaches are measurement-based whereas the approach adopted by IACA is model-based which explicitly takes into account all the admitted flows which traverse the wireless link along with the bandwidth reserved by each flow.

In Most resource-reservation based QoS solutions for wireless multi hop networks were primarily designed for single radio, single-channel network. Most existing approaches in this area are measurement-based approaches in which the bandwidth estimation is typically based on channel idle time ratio which can sometimes lead to inaccurate bandwidth estimation as some flows may not be transmitting at the full rate for which they reserved the channel and the unused bandwidth can be allotted to incoming flows. A number of existing approaches do not integrate intra-flow interference into bandwidth estimation which can lead to inaccurate bandwidth estimation.In the proposed model, the channel is reserved and allocated for multi -radio multi-channel mesh network. IACA is model based approach in which channel allocation is done based on both considering both inter flow and intra flow interference which leads to accurate bandwidth estimation.

3. Network Model

We consider a wireless mesh network in which N number of nodes are there .There are Ri radio interface for each node $i \in N$. were as edge (i, j) in is referred to as a communication link or link, through which the packet is sent and signifies that the nodes i and j can communicate with each other as long as both the nodes have a radio interface each with a common channel. In the network there are K channels available and let K = $\{1, 2, K\}$ denote the set of K available channels.

In few scenarios the number of nodes N is assigned as 50 and all the 50 nodes were dynamic. In few scenarios among the 50 nodes few were made as static and a hybrid network is created. In few scenarios (both in hybrid and dynamic mode) the nodes were increased from 50 to 250 nodes.

4. IACA Overview

The Interference-Aware channel allocation (IACA) scheme for providing per-flow resource-reservation based bandwidth guarantees in multi-radio multi-channel wireless mesh networks. We assume that each node is equipped with one or more radios and those radios of a node are assigned to non-overlapping channels to reduce interference. Fig .1 represents the Flow diagram of IACA in wireless networks.

4.1 Network Creation

Randomly nodes are created and number of antenna and number of channel for each node has been set. Then connectivity is performed for the nodes by connecting the nodes with their neighbors. Each node must build a neighborhood table. Every node is equipped with multiple radios tuned to non-overlapping channels and the node must discover neighbors on all its radio interfaces Thee neighbors are directly connected to the node and are within its normal transmission range. Neighbor discovery enables the node to identify multi-link neighbors which are connected to the node through more than one interface.

4.2 Clique Formation

Depending upon the neighbors who receive the message, the hop table is updated. In hop table, next hop

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information will be keep on updated by using hop message. Depending on two hops information from hop table a clique is formed. This next hop neighbors is updated in routing table. Finally the node which has to send the packet will access this routing table

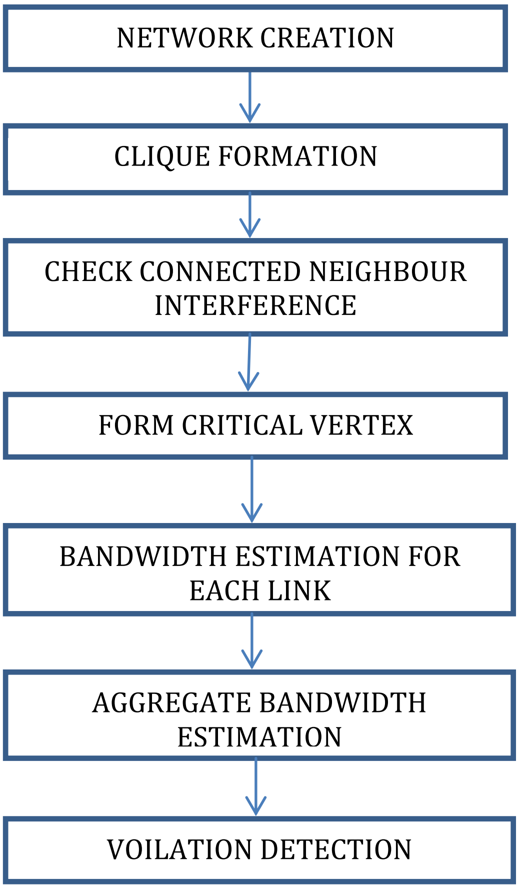

Figure 1: Flow diagram of IACA.

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4.3 Check connected Neighbour interference

Interference modifies, or disrupts information as it travels along a channel between a source and a receiver. The addition of unwanted information to useful information is referred interference. To calculate the expected interference for each node, a temporary list is created in which how many neighbors it has is stored. Finally the node which is connected to minimum number of neighboring nodes through its radio interface is selected as intermediate node to send the packets.

To that particular neighbors which has been selected as intermediate, the number of neighborhood interfaces it has is checked and in such a way for all the path till destination connected neighbors which has minimum number of interfaces is checked and that path which has minimum number of expected interference is selected.

4.4 Formation of critical vertex

A critical vertex is formed, the nodes are sorted in an ascending order fashion, which start with nodes which has minimum expected interference to till node which has maximum expected interference have been sorted in an order.

4.5 Flow rate and bandwidth Estimation

For each link the flow rate that is the rate at which the packets has to be sent in that link should be determined. In this phase, every node estimates the available bandwidth for all the outgoing links using locally constructed conflict graphs by taking into account the interference from the existing flows, and then the intra-flow interference that the new incoming flow will generate with itself is taken into consideration. Finally, the available bandwidths of multiple links are summed up to estimate the bandwidth that each outgoing path can support for the incoming flow.

flow rate = receiving bytes/ current time

4.6 Bandwidth Computation and QoS Violation Detection

For the packet to be sent the bandwidth required is calculated so that the path which has both minimum expected interference and the path which has more residual bandwidth than the required bandwidth is selected. If both of these are satisfied, link is created and request packet is sent to that destination node, once if the node receives the destination packet the route replay is sent through that established links.

As soon as the source node receives the route replay full path is created and data packet is sent to the destination through this established path. The node which does not have the required bandwidth and suppose if it involves in forwarding the packet it is a violating node. These nodes are removed from the routing table and if in case violation detection is found then routing table should be re-updated and the process should start from first.

BWrequired = packet size * 8 * total time / interval

If Av:BW > BWrequired Proceed

Else Stop

As an integral part of this method admission control, load balancing and resource reservation have been accomplished. In admission control the current node checks whether any of the hops can support the required

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bandwidth of incoming flow. If yes, then route request packet is re-broadcasted. If no, then the packet is simply dropped. To provide load balancing the incoming flow is distributed on multiple concurrent links within the clique. The resource reservation is finalized when the intermediate nodes receive the route reply message from the destination. Once if the admission control and resource reservation is over, the source can send traffic to the destination.

5. PERFORMANCE EVALUATION

In this section, we evaluate IACA and we justify it using simulations. Network simulator (NS2) is developed at UC Berkeley and it is discrete event driven simulator. The goal of NS2 is to support networking research field and in education. New protocols can be designed using NS2, the comparison of different protocols and traffic evaluations can be performed. NS2 is developed as a collaborative environment it is an open source and freely distributed. Many institutes and people working in development and research use maintain and develop NS2. Versions are available for Free Linux, Solaris, Windows and Mac OS.

The results of implemented technique have been discussed and the functionality of implemented techniques is simulated. The technique is implemented and functionality is verified by using Network Simulator-

In terms of the Packet delivery ratio (PDR), IACA performs for light load as well as heavy load for the both hybrid and dynamic network topologies. For light to medium load, the difference between the two schemes is relatively small, but the difference in terms of PDR becomes more pronounced as the load in the network increases (due to increasing flow size). In terms of the end-to-end delay for flows, IACA consistently performs better than existing methods. The averaged results across various topologies provide a better picture of IACA under general scenarios. Intuitively, the reduction of congested regions in the network by IACA leads to fewer collisions and therefore fewer link-layer retransmissions. This leads to reduction in end-to-end delays. For both schemes, the delay increases in general with the increasing load in both scenarios. The delay is more in hybrid scenario than in dynamic scenario. In terms of throughput IACA scheme, we see that the scheme works well and allows admission of all 7flows. However, when flow size increases it should have refused admission but, we see that the IACA scheme works well as the bandwidth estimation is more accurate since it takes into consideration both the intra-flow as well as inter-flow interference i.e. the interference within the clique as well as outside the clique. This results in correct admission control decision which prevents overburdening the network by rejecting the admission of flow 6 and 7 for which there is not enough bandwidth available.

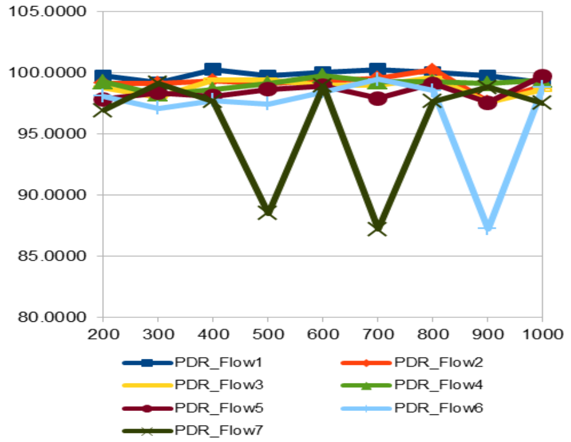

Figure 2: Packet delivery ratio vs. Packet size in Dynamic mode

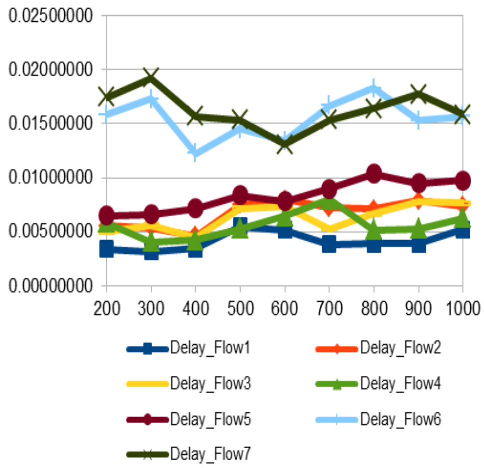

Figure 3: Delay vs. Packet size in Dynamic mode

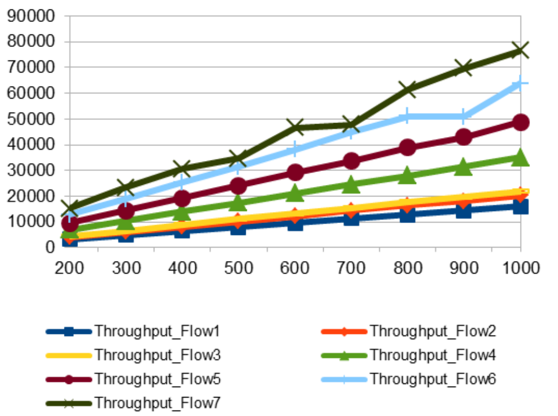

Figure 4: Throughput vs. Packet size in Dynamic mode

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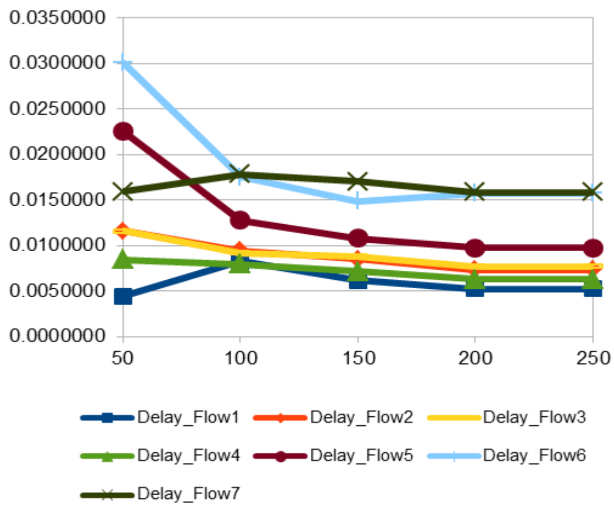


Figure 5: Traffic vs. delay in dynamic mode

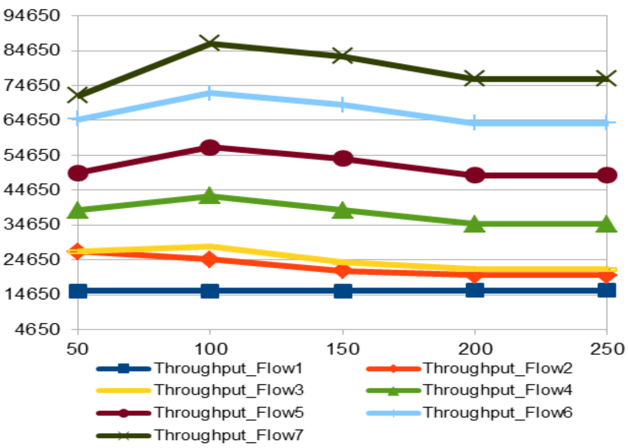
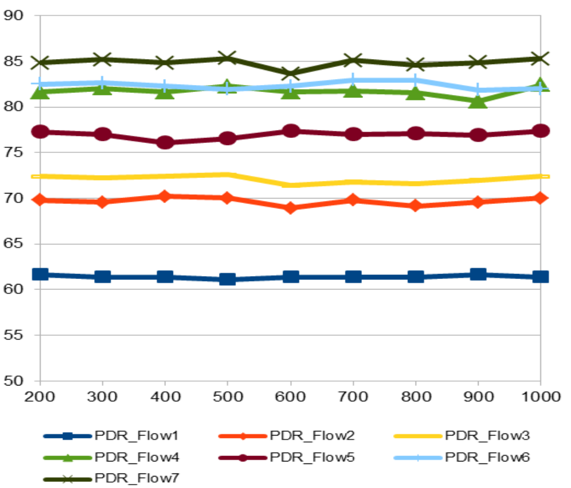


Figure 6: Throughput vs. traffic in dynamic mode



Figu
re 7: PDR vs. packet size in hybrid mode

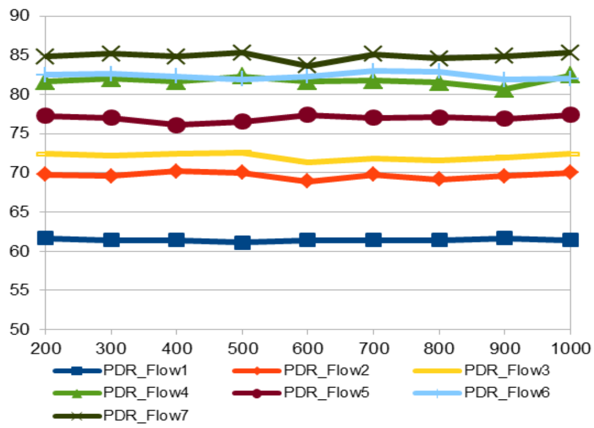


Figure 8: PDR vs. packet size in hybrid mode

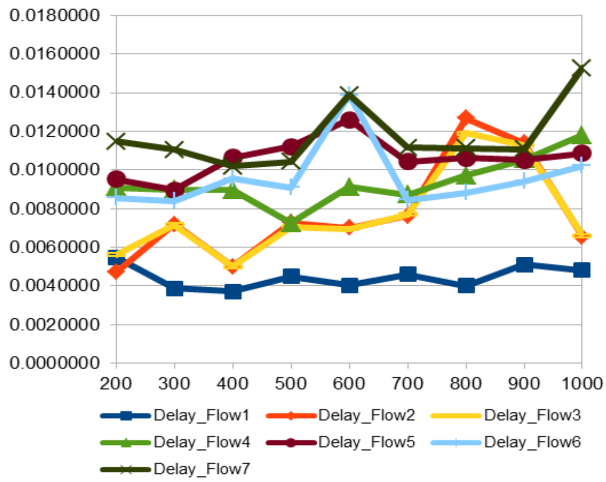


Figure 9: Delay vs. packet size in hybrid mode

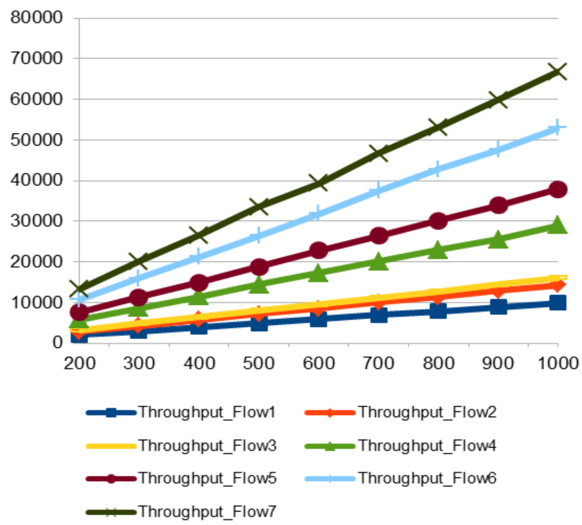


Figure 10: Throughput vs. packet size in hybrid mode

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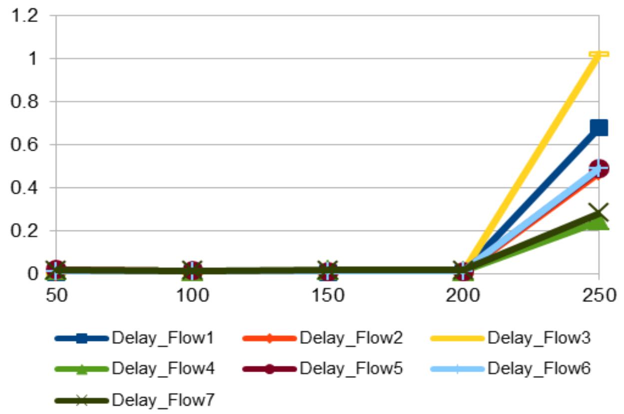

Figure 11: Delay vs. traffic in hybrid mode

6.CONCLUSION

Providing QoS guarantees in multi-channel muti-radio wireless mesh networks is a challenging task. This paper focus on the problem of providing end to-end bandwidth guarantees to flows in multi-radio multi-channel wireless mesh networks. The Interference-Aware channel allocation (IACA) scheme is proposed to provide per-flow bandwidth guarantees in multi-radio multi-channel mesh networks. IACA proposes a model to capture the interference in the mesh network in order to provide accurate bandwidth estimation and correct admission control in contrast to the mostly measurement based existing approaches. Moreover, IACA contributes by exploiting link-diversity in multi-radio multichannel mesh networks. IACA models all available wireless links between two nodes over a wireless hop as one logical link with bandwidth equivalent to sum of bandwidths of comprising links. This enables a significantly higher flow admittance ratio compared to traditional solutions. Moreover, IACA offers efficient load-distribution over the network by distributing the traffic of an incoming flow on the outgoing links by taking into account the interference already present on the links.An analysis is made between dynamic and hybrid scenarios. The simulation result shows that channel allocation in better in IACA.

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