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Optimal Resource Allocation in Wireless Mesh Network

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Abstract- Flow control in a wireless mesh network is an optimization problem. The task is to maximize the aggregate utility of elastic traffic sources. The work has been a basis for analysing various transport-level (including TCP-based) congestion control algorithms. The task takes is to analyse the self-interference of flows and assigns channel, level of transmission power and time slots to each link. Such that the minimum rate requirements of all coexisting flows are met, the rates at which each traffic source will send packets is optimized.

Keywords: WMN, QoS, self-interference, mesh frames, and link cost.

I. Introduction

Wireless mesh networks (WMNs) are emerging as a key solution to provide broadband and mobile wireless connectivity in a flexible and cost effective way. Wireless mesh network can be taken into account using 802.11, 802.15, 802.16, cellular technologies combining more than one type of such technologies. In such situations, it is likely that the shared spectrum is not enough to meet all demands, congestion can persistently occur; hence coordination or cooperation mechanisms are needed between independent and opportunistic users' routers to manage reciprocal interferences and resource allocation and avoid performance degradation during congestion cases. We can refer to such networking cases as collaborative wireless mesh networks. Compared to other nodes in the network mesh routers doesn't remain limited in terms of resources and thus more resources intensive function can be exploited to perform. Thus the wireless mesh network in many aspects differs from other ad-hoc network because these nodes are more often constrained by subjected resources.

Resource allocation plays a significant role in designing efficient and reliable wireless networks. However, a generic approach is still not available due to the challenging wireless environments, the degrees of freedom of the wireless resources, the heterogeneity of wireless networks, etc. There are many investigated several resource allocation problems for typical wireless transmission scenarios, the roles of learning, competition, and coordination in multiuser communication Systems. Resource allocation may be decided by using computer programs applied to some specialized domain to automatically and dynamically distribute resources to applicants. It is taken as one of the issue of a specialized case of automatic scheduling.

The focus is on to analyse a framework to address the problem of maximizing the aggregate utility of traffic flows in a multi-hop wireless network, with constraints imposed both due to self-interference and minimum rate requirements. The parameters that are needed to maximize the utility are transmission powers of individual nodes and the channels assigned to the different communication links. It is based on using a cross decomposition technique that takes both inter-flow interference and self-interference into account. [1]

The output of the framework is a schedule that shows what links are activated in each slot and the parameters associated with each of those links. In case of the minimum rate constraint doesn't get satisfied for all of the flows, then framework intelligently reject a sub-set of the flows and recomputed a schedule for the remaining other flows. Here also analyse an admission control scheme which determines if new flows can be admitted without violating the rate requirements of the existing flows in the network. [1]

A. Advantages of Proposed System

- 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.

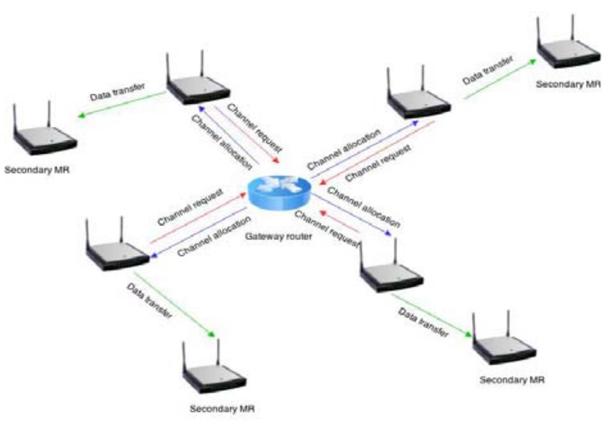

Fig 1 Basic structure of resource allocation scheme

II. LITERATURE SURVEY

[1] In more detail, author adapted an approach 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.

A. Channel Assignment

The proposed 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. 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. The proposed 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 proposed 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 neighbour 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. This sum is calculated for each of the channels and the channel with the least associated value is selected for the link. The proposed channel assignment is summarized in implementation phase, which define Q(c) to be the set of links that are assigned channel c. An active link is then assigned a transmit power based on our power assignment algorithm discussed next.

B. Performance of Proposed Resource Allocation

The proposed resource allocation strategy is in terms of its efficiency and convergence. In particular, it provides the complexity order of proposed resource allocation scheme, and compares the performance of our approach with that of an optimal schedule (produced by exhaustive search).

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. Coordination between the two layers can be implemented on different timescales: end-to-end rate allocation (through TCP/AQM) on the fast time-scale and incremental channel and power updates on the slow time-scale. As demonstrated in most of the common TCP/AQM 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 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 in Section V-B; it then augments the schedule. The procedure is then repeated with this revised schedule.

Implementing the proposed algorithm is viable following IEEE 802.16 standard. A mesh frame consists of control and data sub frames, and therefore two schedules are required for centralized operations, one for the control sub frame and one for the data sub frame. The control sub frame is used for exchanging centralized scheduling messages. Assuming all that routers in the network are time synchronized, a router calculates its control schedule by extracting a breadth-first topology-based tree included in a mesh centralized schedule configuration message transmitted by a wireless mesh network (WMN) gateway. Given the control schedule, each router transmits its link price information using a mesh centralized schedule message request to the gateway. On receiving all messages, the gateway propagates message grants, which include channel and power allocation information for the data sub frame schedule augmented.

C. Admission Control

In this section extend the primal-dual framework to support admission control to handle dynamic settings where flows enter and exit the network.

1) Handling Infeasible QoS Requests

The proposed resource allocation framework attempts to achieve both fairness and the QoS requirements as specified by the utility maximization problem. If sum of QoS requirements of the various sources on a link exceeds the link capacity, the link cost, represented by λ, will not converge; it will increase continuously as we progressively go through time (in terms of slots) and this leads to an infeasible solution. In such a scenario, the only solution would be to gradually drop a subset of the sources until the rate requirements of the rest of the sources are met. The objective could be to drop as few sources as possible. For any link, if the link cost increases by γper slot during χ consecutive slots, a schedule is considered to be infeasible. In order to handle this infeasible scenario, they first solve (8) with rreqs relaxed to 0 for every source s $\in$S. Each source *s* whose assigned rate meets its QoS requirement (i.e., rs$\geq$ rreqs) is put into a set G; the other nodes are put into a set G. Members in G are the sources that are candidates for being dropped. Here consider three dropping policies or rules. As per the first policy, choose the source for which, the difference or gap between the required rate and the assigned rate is the maximum. The rule is referred to as MG (for maximum gap). After removing the above source from G, solve the relaxed form again with the sources in G. The process is repeated until no sources are left in G, i.e., until there is no active source for which the QoS requirements are not met.

2) Admission Control

An admission control strategy is essential to provide protection to the sources that are currently being serviced. In other words, the QoS of existing flows in terms of a minimum rate (being currently provided) cannot be compromised in order to accommodate new incoming flows.

III. IMPLEMENTATION

The framework takes into account the self-interference of flows by

- Channel assignment management
- Adaptive resource allocation
- Admission control
- Network manager module

A. Assumptions and Dependencies

The following assumptions have been made in resource allocation

- It is assumed that nodes are divided as source nodes and receiver nodes.
- Nodes are deployed in random fashion.
- All the nodes are set up in the Topology Generator Manager have same energy consumption.

Dependencies

- The project work requires Atarraya package installation.
- Proper configuration of the network has to be done before executing the application.

During the transmission of packets through one link the other links will remain deactivated or in sleep mode to avoid congestion due to self interference and co channel interference.

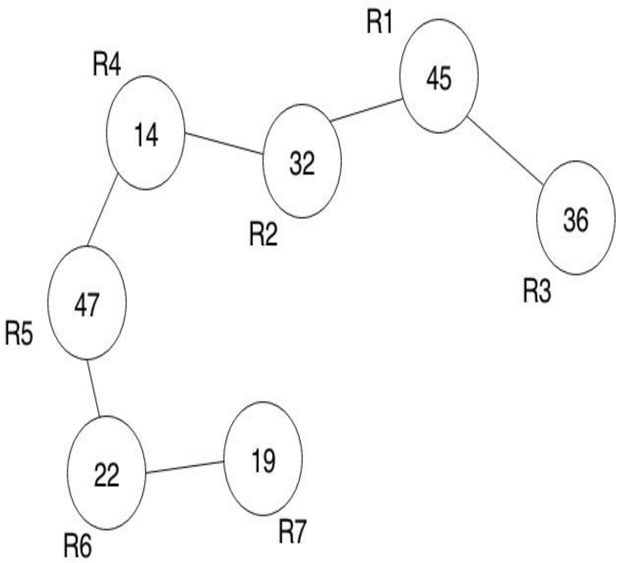

Fig 2 A 7-node Wireless Mesh Network; a link indicates an interference relationship and the value indicates nodes' demand [8]

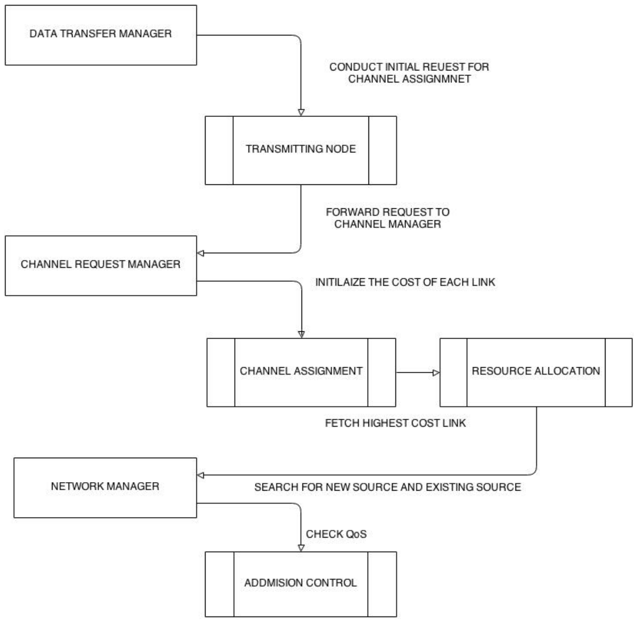

Fig 3 Dataflowdiagram

B. Algorithm [1]

1) Channel Assignment

Step 1: Initialize the link creation process.
Step 2: Sort the link in descending order of link cost.
Step 3: calculate the cost of each link with number of nodes collaboratively. J=1 to L do
Step 4: Allocate channel with highest cost link.
Allocate channel c_j= argmin$_c${d1, d2,...., d_c} to link $L_{j;}$
Step 5: If yes, then assign channel to Link.
Assign L_j to Q(c_j);
Step 6: If no, then again go for assigning channel.

2) Adaptive Resource Allocation

Step 1: Start sending resources through the assigned channel or link (G or G^1).
Step 2: Calculate the utilization of each channel.
Step 3: Apply the utilization primal dual maximization problem algorithm.
Step 4: If channel can be utilized fully put the channel in G link.
Put s into G such that $r_s \geq r^{req}$;
Step 5: Otherwise, put into G^1.
Remove k from G^1such that k = argmax$_{s \in G1}$($r_s^{req} - r_s$);
Step 6: End the allocation process.

3) Admission Control

Step1: Initialize the process.
Step 2: scan for new source and existing source.

$E \leftarrow \theta, N \leftarrow \theta$

Step 3: Put the existing source into E and new source into N.
Step 4: now perform the channel assignment process on this for source E U N.
Step 5: If feasible then run the resource allocation algorithm and get G.
Step 6: Reject a new source with maximum QoS requirement in N.
Step 7: If not feasible admit all new sources in N. Allocate feasible link to the new sources

C. Deployment Process

- In atarraya tool first need to create deployment and then go for visualization and will set the TC protocol to energy efficient routing protocol.
- Then we will go for selecting the nodes and connecting to link accordingly to low cost to high cost.
- In the next step we will go for selecting low cost link, then medium cost link, to high cost link respectively.
- The pink color dots denote the low cost link, blue color for medium cost link and red for high cost link.
- We will go for selecting the other nodes once the topology has been created.
- After that we will allocate the source nodes and the receiver nodes within this topology. Each link cost has been set in the order of low cost to medium cot to high cost in timeslot basis.
- Yellow dot denotes source and pink denotes receiver.
- Then once the topology has been created and channel assignment is complete we will go for resource allocation.
- Start the Atarraya stimulation process and wait for the packets to flow through the link created in gradual traffic from low cost link to then medium to high cost link.
- Here we can find out the transmission of packets in green line denoting transmission process through this link.
- Packets or resources send from the source to the receiver end will follow any particular path to reach the destination avoiding congestion in every timeslot round, each round having its set time limit already set.
- This deployment once the resource allocation is done will check for new admission if available and then will find out free channel in each time round with in limited data rate requirement.

D. Stimulation parameter

S.No	Parameters	Event
1	Topology Creator	Establishes the connection with the node if the neighbor nodes comes in the communication of the nodes
2	Source Connector	Establishes the connection between the source node and router id
3	Link Cost Assigner	Assigns the Cost to the links as low priority, medium priority and high priority
4	Data Transfer module	Transfers the data from one connected link to another towards the receiver
5	Adaptive Link Activation	Activates a link via adaptive methods and deactivates other links in each round
6	Source data generator	Checks whether the link is active and transfer the data to the connected node

IV RESULT AND SNAPSHOT

Stimulation result shows

- What link are to be activated in each time slot and
- The parameter associated with each timeslot.
- Active links.

The result graph will show the number of packets send at each round through different cost links.

- The horizontal axis will show the number of rounds and the vertical axis will show the packet sent count.
- First we will check the packet sent count. Each round will show the number of packets sent through the low cost link, medium cost link and the high cost link.
- The second graph will show the receiver count at each round from different cost links.
- The final graph will provide us with the number of active link at each round.
- During the transmission or communication through a link the other links will remain deactivated or in sleep mode to avoid congestion due to self-interference and co channel interference.

A. Send Count

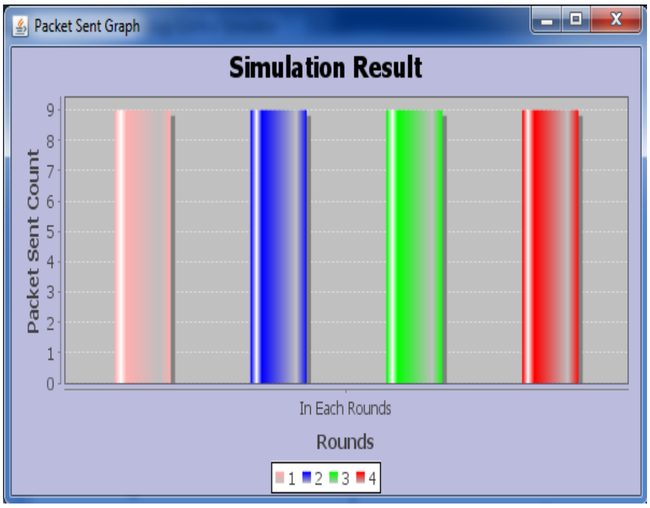

Fig 4 packet sent graph

B. Receiver Count

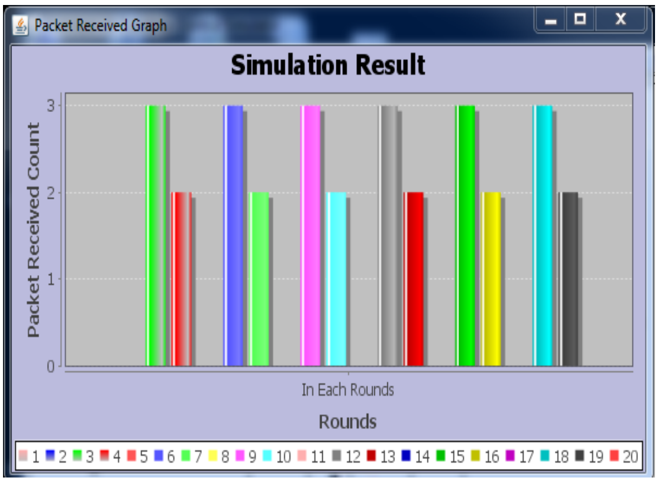

Fig 5 packet received graph

C. Active Links

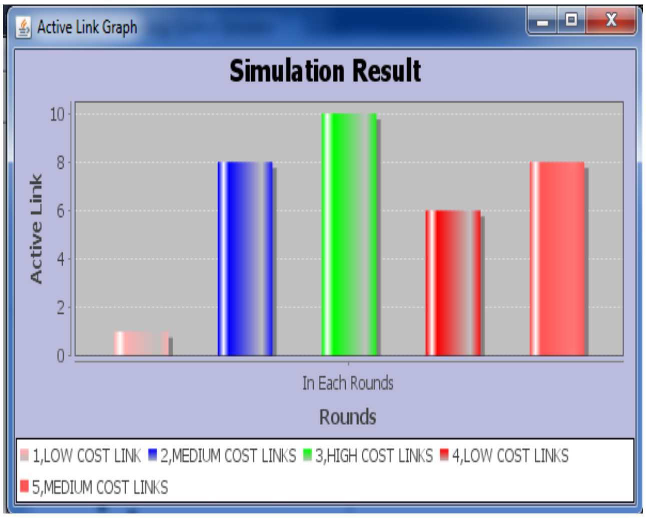

Fig 6 Active link graph

V. CONCLUSION

The main contribution towards this project is to analyze a resource allocation framework by maximising the aggregate utility in wireless mesh network irrespective of the constraints arises due to self-interference and providing optimal resources transmission. The framework selectively drop packets or few of the sources and retransmit sources among the other links to met quality requirement. Wireless channel imposed requirement and QoS requirement both has been well judged in the whole proposed work.

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