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Enhanced QoS Support with Self Reconfigurable Wireless Mesh Networks

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***Abstract*—Support for multimedia quality of service (QoS) is critical and necessary requirement for next generation wireless networks. Wireless Mesh Networking is envisioned as an economically viable paradigm and a promising technology for supporting multimedia QoS. To maximize the *aggregate* utilization of traffic flows in a multi-hop wireless network, with constraints imposed *both* due to self-interference and minimum rate requirements, various parameters are taken into consideration .they are individual nodes transmission powers and the channels assigned to the different communication links. During their lifetime, multi-hop wireless mesh networks (WMNs) experience frequent link failures caused by various reason such as channel interference. These failures cause severe performance degradation in WMNs. This paper presents an *Autonomous network Reconfiguration System* (ARS) that enables a multi-radio WMN to autonomously recover from local link failures to preserve network performance. We provide numerical results to demonstrate the efficacy of our framework.**

***Keywords*— Wireless Mesh Network (WMN), QoS, Resource allocation, admission control, Autonomous network Reconfiguration system**

I. INTRODUCTION

A wireless mesh network (WMN) is a communications network made up of radio nodes organized in a mesh topology. Wireless mesh networks often consist of mesh clients, mesh routers and gateways. The mesh clients are often laptops, cell phones and other wireless devices while the mesh routers forward traffic to and from the gateways which may, but need not, connect to the Internet.

With the recent advances in wireless and mobile communications, supporting multimedia Quality of Service (QoS) becomes a necessary while achievable requirement in wireless networks. Wireless Mesh Networking is envisioned as an economically viable paradigm and a promising technology for supporting multimedia QoS [1].To meet these demands, it requires interdependent functionalities that may include (a) congestion control or rate control: controls the rate to inject traffic into the network by various traffic sources which shares the network (b) resource allocation: In order to meet necessary requirement of each connection, resources are allocated to different connection (c) admission control: It ensures that newly admitted connection do not cause any effect on minimum rate requirement of existing flows.

In wired network, the resource allocation and congestion control problem has received lot of attention. In their seminal work Kelly *et al* [2] have model the problem of flow control as an optimization problem, in which the objective is to maximize aggregate utility of elastic traffic sources subject to capacity constraint on links that made the network. Inspired by Kelly's work there has been a follow u work [7], [8], [9], where TCP congestion control is modeled a convex optimization problem, the objective is to maximize the an aggregate user utility, in these efforts primal and dual solutions to the problems are proposed.

There has been a lot of work and efforts on extending congestion control framework to wireless network. In contrast to wireline network, the wireless link capacity is dependent on other flows in the network but on the other flows that uses the links on the same channel and external interference. Protocols presents at link layer and transport layer are responsible for regulating dependencies between the flows. More importantly, under conditions of self-interference where flow of packet interfere with other packet, in the same flow along multi-hop path.

To maximize the aggregate utility of traffic sources, the framework takes into account self interference if flows and assign (1)channel (2) transmission power levels (3) time slot to each link. It also dictates the rate at which each traffic sources will send packet such that minimum requirement of all flows are met. For all flows if minimum rate requirement is not met then framework rejects subset of flows and recomputes schedule and allocate resources to each of the remaining flows[23]. Multi-hop wireless mesh networks (WMNs) experience frequent link failures that are caused due to channel interference, catastrophic failures and/or application bandwidth demand that may result in performance degradation in WMN. This paper presents an Autonomous network Reconfiguration System (ARS) that enables a multi-radio WMN to autonomously recover from local link failures to preserve network performance.

II. RELATED WORK

Kelly e*t al* in [2], model the problem of flow control as an optimization problem in wireline network. To maximize aggregate utility of traffic sources multiplicity, there has been a lot of work for analysing various transport level congestion control algorithm. This follow up appear in [7], [8], [9]. For extending the wired congestion control framework to wireless network, lot of research activity has been done. In wireline link, capacity of link is fixed. But in contrast to it, the capacity of wireless link is not fixed. As it discussed earlier, link capacity depends upon interference that occur due to other flows, which in turn is regulated by protocol at various layer. Thus, wireless network congestion control has cross layer dependencies. Congestion control cross layer optimization problem can be divided into two sub-problems using mathematical decomposition techniques: rate control problem and scheduling problem to be solved at transport layer and link layer respectively; latter is related to underlying resources to be managed. Various approaches have been proposed independently for the two layers. In [3], [4], [5], [6] link scheduling with contention control has been studied. Management of various resources at lower layer has been looked at in [14], [15], [16], [17]. Congestion control with power control has been studied in [18]. Soldati *et al* in [20]; formulate link scheduling problem. Joint impact of link scheduling and routing are considered in [19]. Routing, power control and link scheduling has been considered in [21] while channel assignment, routing and link scheduling are considered in [22]. Scheduling algorithm's design and their performance evolutions appears in [10], [11], [12], [13]. The various efforts and works that have been done earlier, doesn't consider the problem of resource allocation with QoS support in terms of providing minimum data rate to flows, in the presence of self-interference by considering link failure in mesh network. Autonomous network Reconfiguration System (ARS) that enables a multi-radio WMN to autonomously recover from local link failures to preserve network performance. This can be considered in our work.

III. SYSTEM MODEL

Here we consider preplanned wireless mesh network (WMN) which consisting of set of stationary wireless nodes (routers) connected by set of unidirectional links L. Some of the assumed to have a ability to perform gateway's function and one of them is selected to act as gateway to the internet. Each node is associated with one of orthogonal channel C for transmitting or receiving and is equipped with a single network interface card (NIC). Communication between sender-receiver pair takes place if both of them are tuned to the same channel. Dynamic channel switching is assumed to be possible with NIC in this work. At any time a node can either transmit or receive because nodes operate in half-duplex manner, On link l transmission power pl is assumed to be chosen in $[0,pl_{max}]$ .The signal transmitted by a sender to be decoded properly at receiver, the signal to interference and noise ratio (SINR) should be no less than threshold β. In addition , it is assumed that in a time slotted mode the network operates; slots of equal duration the time is divided.

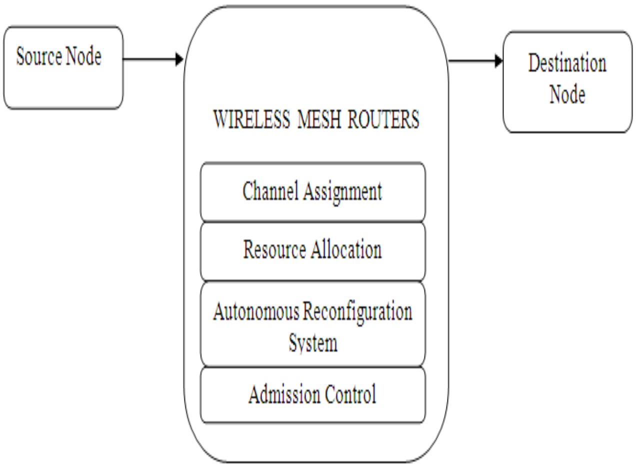
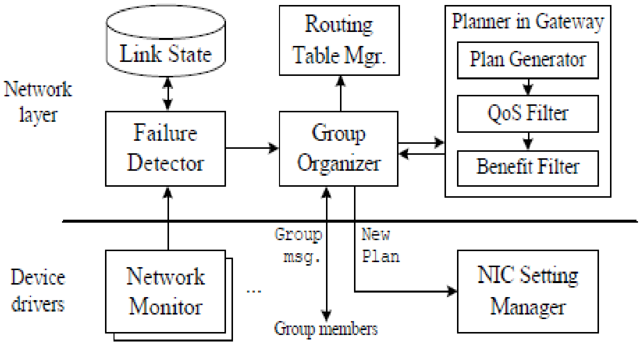


Fig 1:Proposed Architectutre

System is modelled for wireless mesh network.In this model as shown in Fig 1 the channels are assigned based on the size,after channel assignment resources are allocated.



ARS software architecture in each node

Fig 2: ARS Software Architecture

If there is link failure then ARS is used for checking the status of all the links across the source to destination path as shown in Fig 2. If no failure, then data will be transferred, else after reconfiguring the links by network planner, data will be send to destination.

The network has elastic sources S and each source s has an associate data rate rs. In order to satisfy QOS requirement, we assume that each source s requires at a very least, a date rate rs_{req}. Furthermore the data rate may be provided to S is assumed to be upper bounded by rs_{max}, this corresponds to the peak sending rate of S source and depends on application requirements at s. Each s source has an associated utility function Us(rs). The QOS provided to source s when it is injecting packets into network at a rate rs is directly reflected by utility assume utility function to be continuously differentiable . Monotonically increasing, positive and strictly concave over [rs_{max}]. To find optimal resource allocation in terms of transmit power ,time slots and assigning channels ,so as to maximize the source utilities sum ,at the same time, in terms of minimum rates their QOS requirement have to be met.

IV. PROBLEM FORMULATION

This section formulate resource allocation problem with desired objectives and constraints. We then introduce traditional approach developed for wired networks. This forms a basis for our resource allocation framework described in section V.

The path that is used by sources s in order to reach gateway in WMN is represented by routing vector V, the elements of V
are given by:

$$v(l,s) = \begin{cases} 1, & \text{if source } s \text{ uses link } l \\ 0, & \text{otherwise} \end{cases} \tag{1}$$

For l ε L and s ε S

We also define binary channels assignment vector Y with element y(l, c) defined by:

$$y(l,c) = \begin{cases} 1, & \text{if link } l \text{ uses channel } c \\ 0, & \text{otherwise} \end{cases}$$

For l ε L and c ε C (2)

Since each node is equipped with signal NIC .At most one channels is assigned to a link to this end following constraint shall be satisfied for each l link: in y(l, c) as c=1,2,3,.,.,.,.,C

$$y(l,1) + y(l,2) + y(l,3) \ldots\ldots + y(l, C) <= 1, \text{ For all } l \ \varepsilon\ L \tag{3}$$

Next, to account for self-interference we impose constraints among the links. In particular, each node can send to and receive from other nodes in half duplex manner. Thus, two links shares a node. here links are not permitted to active simultaneously. This condition can be presented formally. Set of neighbouring links is represented by E (l) which shares either sender or receiver of link l , the following constraint should be satisfied for l link to be active in a time slot:

$$\sum_{c=1}^{C} \left(y(l,c) \sum_{e\, \varepsilon\, E(l)} y(e,1) + y(e,2) + y(e,3) + \ldots.. + y(e, C) \right) = 0, \quad \text{For all } l\ \varepsilon\ L \tag{4}$$

We are essentially ensuring that no link is adjacent to considered l link is active at same time as l, i.e., no adjacent links are active simultaneously, by forcing the product within summation to be zero

The intersection of (1) (3) and (4) produces active link set Π;

$$\Pi = \left\{ Y \mid y\ \varepsilon\ \{0,1\} \bigcap \sum_{c} y(l,c) \le 1 \right.$$
$$\left. \bigcap \sum_{c} \left(y(l,c) \sum_{e} \sum_{h} y(e,h) \right) = 0, \quad \text{For all } l\ \varepsilon\ L \right\} \tag{5}$$

The following two sets are established for source rate and transmit power, based on assumption on rs and pl, respectively.

$$\psi = \{ R \mid rsreq <= rs <= rs_{max}, \text{ for all } s\ \varepsilon\ S \},$$
$$\Delta = \{ P \mid 0 <= pl <= pl_{max}, \text{ for all } l\ \varepsilon\ L \} \tag{6}$$

Where R and P are the S x 1 rate vector and L x 1 power vector , respectively.

In contrast to wired network link, in a wireless network capacity of link is not fixed due to shared nature of wireless medium. We assume that link that experience the interference can be modeled as Gaussian random variable. Channel is exposed to additive white Gaussian noise (AWGN), the capacity of l link hl, can be expressed as hl=log(1+K.SINR(l))/T, where T is symbol period depending on the modulation scheme used K is constant and on link l ,SINR(l) is signal to interference and noise ratio and is given by:

$$SINR(l) = \frac{pl\ gll}{\sum_{m \neq l\, \varepsilon\, L} Ym \cdot Yl^{T}\ pm\ glm + \eta_{l}} \tag{7}$$

Where pl transmit power of sender on link L and Yl is the l th row vector of Y, and ηl is the additive thermal white noise power,glm is the link gain between the receiver on link l and the sender on link m. Link capacity non linear function of transmit power P and assign channel Y we denote L x 1 link capacity vector $(h_{1,\,.\,.\,.\,.,}h_{L})^{T}$ denoted by H(Y,P).

In WMN the target resource allocation can then be formulated as following utility maximization problem:

$$\begin{array}{ll} \text{Max} & 1^{T} \cdot U(R) \\ \text{s . t} & V.R <= H(Y, P)\,, \\ & Y\ \varepsilon\ \Pi\,, \\ & P\ \varepsilon\ \Delta\,, \\ & R\ \ \varepsilon\ \psi, \end{array} \tag{8}$$

Where 1 is L x S unit vector and U(R) is S x 1 vector of utility function (U1 (r1) ,...., US (rS))^{T}.

V. RESOURCE ALLOCATION FRAME WORK

This section presents framework which address the utility maximization problem , defined by (8). The traditional primal-dual method [2] to utility maximization problem can be conceived as solution method. By introducing the Lagrange multipliers $\lambda=(\lambda_1,\lambda_2,\ldots\ldots\lambda l)$, the primal-dual technique separates problem into smaller sub-problem with regard to first constraint in (8) .The original problem then becomes:

$$\begin{array}{ll} \text{Max} & L(\lambda, R, P, Y) \\ \text{s.t} & Y\ \varepsilon\ \Pi\,, \\ & P\ \varepsilon\ \Delta\,, \\ & R\ \ \varepsilon\ \psi, \end{array} \tag{9}$$

Where $L(\lambda, R, P, Y) = (1^{T} \cdot U(R) - \lambda.V.R) + \lambda . H(Y,P)$ problem (9) can be divided into two sub-problems due to its separable structure ,they are , the congestion control problem and scheduling problem. The congestion control problem is defined by:

$$\begin{aligned} \text{Max} \quad & 1^T \cdot U(R) - \lambda . V .R \\ \text{s.t} \quad & R \,\varepsilon\, \psi \end{aligned} \qquad (10)$$

Here the aim is maximization of sum of each source's utility gain by choosing the optimal sending rate for each such source .Using the congestion control mechanism at the transport layer this problem is solved. The scheduling problem is given by

$$\begin{aligned} \text{Max} \quad & \lambda . H(Y, P) \\ \text{s.t} \quad & Y \,\varepsilon\, \Pi , \\ & P \,\varepsilon\, \Delta , \end{aligned} \qquad (11)$$

Where λ, the problem is now to determine the best usage of link that compose the network. Note that if link is assigned zero power or has received no channel assignment then link will not be active. While solving the scheduling problem both physical layer and link layer are involved.

The primal-dual method's basic operation involves determining source rates and resources distributively by solving (10) and (11) with given λ,updating λ based on the value of source rates and resources. To (8) naive application of primal-dual method may not work properly for following reasons. First, the primal-dual approach implicitly assumes that, while computing the optimal end to end rate for the paths all the links on the end to end path are simultaneously active.

Incorporating the self-interference constraint in (5), however in each interaction it results in the activation of only

a few links. Consequently, the computed rates may be simply be zero for most of the paths. Second, the primal-dual approach assumes that optimally scheduling problem (11) can be solved.

Given the set Π characteristics in (5), the problem is proven to be NP-hard. Thus at every iteration finding the optimum will cost prohibitive levels of computational resources and time.

First issue is addressed by leveraging the cross decomposition technique. Using this technique in a nutshell over multiple time slots we build a link schedule, conforming to the constraints. In V-A this module is discussed. Second issue is addressed by proposing an efficient resource algorithm in section V-B.

A. Cross decomposition approach in detail:

We reformulate (8), in order to leverage the cross decomposition technique as,

$$\begin{aligned} \text{Max} \quad & \rho\,(H(Y, P)) \\ \text{s.t} \quad & Y \,\varepsilon\, \Pi , \\ & P \,\varepsilon\, \Delta , \end{aligned} \qquad (12)$$

Where $\rho\ (H(Y,P)) = \{\max\ 1^T \cdot U(R) \mid V \cdot R <= H(Y,P)$ and $R \,\varepsilon\, \psi\}$ for a fixed link capacity vector $H\ (Y,P)$ whose elements are all positive. By using the traditional primal-dual method $\rho(\ H, P\ )$ is solved and link cost vector λ is obtained correspondingly. By augmenting active links the schedule is updated. These active links are found by solving scheduling problem (11), with obtained λ. An average link capacity is newly calculated based on the augmented schedule and input into the problem for maximizing ρ. The procedure repeats until the problem has been classified s infeasible or rate have converged. In [16], the convergence of cross decomposition approach has been previously studied; the method converges faster than the mean value cross decomposition method. Using cross decomposition , the primal-dual approach is revised and summarized in Algorithm 1(Fig 3).

B. *Resource Allocation Approach :* The proposed primal-dual approach requires at every iteration the scheduling problem (11) to be solved.

At intersection k, the scheduling problem (11) is then expressed as;

$$\begin{aligned} & \max_{\substack{Y \,\varepsilon\, \Pi \\ P \,\varepsilon\, \Delta}} \sum_{l} \lambda l^{(k)} \log\left(\frac{pl\ gll}{\sum_{m \neq l \,\varepsilon\, L} Ym \cdot Yl^T\ pm\ glm} \right) \\ & = \max_{\substack{Y \,\varepsilon\, \Pi \\ P \,\varepsilon\, \Delta}} \sum_{l} \lambda l^{(k)} \left(\log\,(pl\ gll) - \log\left(\sum_{m \neq l \,\varepsilon\, L} Ym \cdot Yl^T\ pm\ glm \right) \right) \end{aligned} \qquad (13)$$

Solving (13) is very complex. The major difficulties arise for solving (13) because; it requires a combinatorial decision in terms of channel and power assignment. Thus at every iteration finding the optimum will cost prohibitive levels of computational resource and time. Given this, to find an approximate solution to (13), we propose an efficient two phase approach. Channels are assigned to link as per simple heuristic in the first phase and in the second phase the optimal powers are calculated for the links.

Algorithm 1: Proposed Primal –Dual Algorithm

```
1: Initialization: Schedule links using pure TDMA for the first L slots. $k \leftarrow L + 1$
2: loop
3: Calculate $\rho\ (H`(Y^{(k)},P^{(k)})$ by using the traditional primal-dual approach for $H`(Y^{(k)},P^{(k)})$ , and let $\lambda^{(k)}$ be the obtained equilibrium link price;
4: Calculate$(Y^{(k+1)},P^{(k+1)}$ ) by solving the scheduling problem (11) for $\lambda^{(k)}$, and augment the schedule with the associated active links;
5: Calculate the average link capacity $H`(Y^{(k+1)},P^{(k+1)})= \{ H(Y^{(1)},P^{(1)}) + H(Y^{(2)},P^{(2)}) +\ldots\ldots+ H(Y^{(k+1)},P^{(k+1)})\} / (k+1)$
6: $k \leftarrow k + 1$;
7: end loop
```

Fig 3: pseudo- code for proposed Primal-Dual approach

1) Channel Assignment : Channels are allocated by proposed algorithm in a way that i) self–interference is avoided and ii) co-channel interference levels among links that use the same channel are kept as low as possible. Links that have higher cost are assigned higher priorities in terms of channel assignment over the links with lower cost using Algorithm 2. By sorting the links in descending order of their link costs the proposed channel assignment algorithm starts. Then channels are assigned to links in that order. Self-interference is avoided by proposed algorithm by not assigning a channel to any link whose incident links have already been assigned channels.

```
Algorithm 2: Channel assignment Algorithm
1: Initialization: $y(l, c) \leftarrow 0$, and $Q(c) \leftarrow \phi$, for all $l \in L$ and for all $c \in C$;
2: Sort links by descending order of $\lambda$, and label $i^{th}$ link in the sorted list as $l_i$;
3: for $j = 1$ to $L$ do
4:     if $\Sigma_e \Sigma_c\, y(e, c) = 0$, for $e \in E(l_j)$ then
5:         Calculate $d_c = \Sigma_{q \in Q(c)}\, g_{q\,j}^{\,l}$, for all $c \in C$;
6:         Allocate channel $c_{l_j} = \mathrm{argmin}_c \{d1, d2, . . . , dC\}$ to link $l_j$ ;
7:         Assign $l_j$ to $Q( c_{l_j} )$;
8:     end if
9: end for
```

Fig 4: pseudo-code for channel assignment

In order to alleviate the effect of co-channel interference, based on the sum of link gains between all the interfering sender using the same channel and the receiver of link. The channel that is assigned to a link is selected for each of the channel. This sum is calculated and channel with the least associated value is selected for the link. Algorithm 2 summarizes the proposed channel assignment ,where Q(c) be the link set that are assigned channel c. Based on our power assignment algorithm as discussed next, an active link is then assigned transmit power.

2) *Power Control:* With channel assignment as described in previous section we have $Y^{(k)}$ specified at the beginning of k slot. Let $m^{'}$ be the link set member satisfying $Y_{m`}^{(k)} . (Yl^{(k)})^T = 1$ for $m`$ is not equal to 1.The scheduling problem (13) is then reduced to

$$\max_{P \varepsilon \Delta} \sum_{l} \lambda l^{(k)} \left(\log (pl\, gll) - \log \left(\sum_{m'} pm'\, glm' \right) \right) \tag{14}$$

The problem (14) is non-convex, thus geometric programming is applied for solving it. To transform non-convex problem into convex, geometric programming is used through logarithmic change of variable. Then we can write (14) as

$$\begin{aligned} &\max_{\hat{P} \varepsilon \hat{\Delta}} \sum_{l} \lambda l^{(k)} \left(\log \left(e^{\hat{p}l}\, gll \right) - \log \left(\sum_{m'} e^{\hat{p}m'}\, glm' \right) \right) \\ &= \max_{\hat{P} \varepsilon \hat{\Delta}} \sum_{l} \lambda l^{(k)} \left(\hat{p}l + \log (gll) - \log \left(\sum_{m'} e^{\hat{p}m'}\, glm' \right) \right) \end{aligned} \tag{15}$$

Note that objective function in (15), for each l link, is concave function. It consists of linear and concave terms and concave function's sum is also concave. After transformation problem (15) is thus concave optimization problem for which using efficient technique such as interior point method .

C) Implementation: Both the transport and physical layer requires to be aligned for the proposed approach. Coordination between these two layers can be implemented on different time scales [16]: on the first time scale end-to-end rate allocation (TCO/AQM) and power updates and incremental channel on slow time scale. We run the TCP/AQM scheme until convergence based on the initial schedule. After this, link prices associated with its incoming and outgoing links is reported by each node to the gateway where proposed resource allocation scheme is adopted. After receiving link price from entire node set, the gateway finds the channels and transmit power by applying proposed resource allocation scheme.

Proposed algorithm implementation is feasible. Mesh frame consists of data and control subframes, and therefore, for centralized operation two schedules are required. one for each subframe. Centralized scheduling messages are exchanged by using the control subframe. Assuming that in the network all the routers are time synchronized, control schedule is calculated by router by extracting a breadth-first topology –based tree included in mesh centralized message (MSH-CSCF) transmitted by wireless mesh network gateway. Given the link schedule, using mesh centralized schedule message (MSH-CSCH) request, each router transmits its link price information to the gateway. On receiving all MSH-CSCH messages, the gateway propagates MSH -CSCF grants, which include power allocation information and channel for data sub frame schedule augmented.

VI. ADMISSION CONTROL

The primal-dual framework to support admission control to handle dynamic settings where flow enter and exit from the network dynamically extended in this section.

A. Infeasible QoS Requests Management:

Both fairness and QoS requirements as specified by the utility maximization problem (18) are attempted to be achieved by proposed resource allocation framework. However, in the first constraint of (8), if link capacity is less than the sum of QoS requirement of various sources, then the link cost(λ) will not converge; as we progressively go through time it will increases and leads to an infeasible solution. In this situation, to gradually drop a subset of the sources would be the only solution until rate requirement of the rest of sources are met. To drop as few sources as possible could be the objective.

Algorithm 3: Adoptive Resource Allocation With MG

```
Initialization: $G \leftarrow \phi$ , $G` \leftarrow \phi$
Perform Algorithm 1 on the utility maximization problem (8) with $rs_{req} = 0$, for all $s \varepsilon S$ ;
Put s into G such that $rs >= rs_{req}$ ; Otherwise, put into G`;
while $G \neq \phi$ do
    Remove k from G such that $k = \text{argmax}_{s \varepsilon G`} (rs_{req} \cup rs)$;
    Solve (8) with $rs_{req} = 0$, for all $s \varepsilon G \cup G`$;
    $G \leftarrow \phi$, $G` \leftarrow \phi$
    Put s into G such that $rs >= rs_{req}$ ; Otherwise, put into G;
end while
```

Fig 5:pseudo-code for Adaptive Resource Allocation with MG

Consider each source s whose assigned rate meets its QoS requirement is put into a G set; the other nodes are put into G`,they are the sources that the candidates for being dropped. We consider the three dropping policies. In first, the sources for which, the gap between the required rate and the assigned rate is maximum are chosen rule is called MG (maximum gap). After removing the above sources from G`, again we will solve the relaxed form of (8). This process continues until there is no active source for which the QoS requirements are not met. Algorithm 3 summarizes the resource adjustment method (Fig 5). MR (maximum rate) and MRG are second and third policy respectively. In the case of tie MG is applied .With MRG, MR is applied first and subsequently.

B. Admission Control Approach:

The best strategy used to provide the protection to the sources that are currently being serviced is admission control, i.e; In order to accommodate new incoming flows the QoS of existing flows being provided currently cannot be compromised. To provide support for an admission control, our resource allocation framework can be easily adopted.

Let us assume that new sources possibly multiple sources Ns, each source with its own minimum rate specification, request services. Existing source set called Es. First, by using Algorithm 1, we solves the utility maximization problem (8), with both the existing and new sources. All the new connections are allowed to join the network if and if requested rates are viable. If rates requested are not feasible then Algorithm 3 is invoked. Source in Ns with the largest QoS requirement is dropped. Until all the sources in Ns are either admitted or dropped this process is repeated. Algorithm 4 summarizes this approach (Fig 6).

Algorithm 4: Admission Control Algorithm

```
Initialization: $Es \leftarrow \phi$ ,$Ns \leftarrow \phi$
Put the existing sources into Es and the new one(s) into Ns;
Perform Algorithm 1 on (8) for the sources in $Es \cup Ns$;
if (8) is infeasible then
    Run Algorithm 3 and Get G;
    while $Es \Pi G \neq Es$ and $Ns \neq \phi$ do
        Reject a new source with the maximum QoS requirement in Ns;
        Run Algorithm 3 and Get G;
    end while
    if $Es \Pi G = Es$ then
        Admit all new source(s) in Ns;
    end if
else
    Admit all new source(s) in Ns;
end if
```

Fig 6: pseudo-code for Admission control

VII. AUTONOMOUS RECONFIGURATION SYSTEM

This section describes the ARS system in detail. This section also describes how the link failures are overcome during file transmission inside wireless mesh network. This section consists of five parts, they are as shown below.

A. Network Construction:

We create a network topology to send data. Network maintains both node and connection details. Nodes are interconnected and exchange data directly with each other nodes. Nodes are connected with other nodes in the network. Network server maintains the node IP address, port details and status. Node gives request to server and get the node details from server. A network is assumed to consist of mesh nodes and one control gateway. Each mesh node is equipped with radios, and each radio's channel and link assignments are initially made by using global channel/link assignment algorithms. Multiple orthogonal channels are assumed available. The interference among multiple radios in one node is assumed to be negligible via physical separation among antennas or by using shields. The gateway is connected to the Internet via wire-line links as well as to other mesh routers via wireless links.

B. Route Discovery:

Sends sender node request to receiver node through all possible paths when connection established, and receive the response from receiver. We measure the available routes by getting details from server system. Calculate the path cost value for each available route. We measure the delay time for each available route from source node to destination node. It measures the throughput for each available route from source node to destination node.

C. Path Estimation:

We calculate the minimum delay from source node to destination node. We calculate the sort path cost values. Among the path cost find out the minimum path cost Paths are available means process started to send data from sender node to destination node. Among that available path determine the shortest path, minimum delay time and throughput. We send the data to receive node among these path.

D. Failure Discovery:

Before sending the data , sender node will calculate threshold limit, because it is used to avoid the node failure of the sending data. While sending the data in that shortest path, It checks for the threshold limit. If the threshold limit exceeds, it alternatively measures the backup path with the constraint that the selected path does not have repeated nodes which was available in the previous path. Through this available path, the data from source node to destination node is sent.

E. Autonomous Reconfiguration System:

ARS in every mesh node monitors the quality of its outgoing wireless links at every monitoring period. and reports the results to a gateway via a management message. Second, once it detects a link failure(s), ARS in the detector node(s) triggers the formation of a group among local mesh routers that use a faulty channel, and one of the group members is elected as a leader using the well-known bully algorithm for coordinating the reconfiguration. Third, the leader node sends a planning-request message to a gateway. Then, the gateway synchronizes the planning requests, if there are multiple requests and generates a reconfiguration plan for the request. Fourth, the gateway sends a reconfiguration plan to the leader node and the group members. Finally, all nodes in the group execute the corresponding configuration changes, if any, and resolve the group. We assume that during the formation and reconfiguration, all messages are reliably delivered via a routing protocol and per-hop retransmission timer. Algorithm 5 summarizes the ARS approach (Fig 7).

Algorithm 5: Autonomous System Operation At Mesh Node

```
Step 1: generate topology
Step 2: start flooding information
          A: for every link/node do
          B: exchange neighbour node information.
          C: end for
          D: send neighbour node information to the gateway;
Step 3: select source node,
Step 4: establish path from source to destination
Step 5: start packet transmission
Step 6: check node/link failures else go to step 10
Step 7: start reconfiguration and
            E: generate reconfiguration plan
            F: Re-establish path
Step 8: start packet transmission
Step 9: receive packets
```

Fig 7: pseudo-code for Autonomous System Operation At Mesh Node

VIII. RESULTS

The proposed resource allocation framework's evolution are presented in VII-B1 and the admission control strategy is evaluated in subsection VII-B2.

1) Performance Comparison Between Resource Allocation Schemes: Performance of the proposed channel allocation and power control are evaluated in this subsection. The proposed scheme's performance is compared with that of (a) resource allocation strategy with random channel assignment and fixed power with maximum transmit power(RC-FP), (b)random channel assignment strategy and proposed power control (RC-PC), (c) the congestion-aware channel assignment with fixed power(CA-FP),in which channels are assigned such that link cost and link capacity product is maximized. With the different schemes and considered topologies the average goodput of traffic sources achieved. In summary, higher goodput is achieved by proposed channel and power allocation method than RC-FP, RC-PC, and CA-FP by 125%, 20%, and 74% respectively. In particular, the contribution of power control and channel assignment to the goodput gain is varied depending on the topology type (Fig 8). The proposed power control contribution is evaluated through the ratio of power control gain to the total gain.

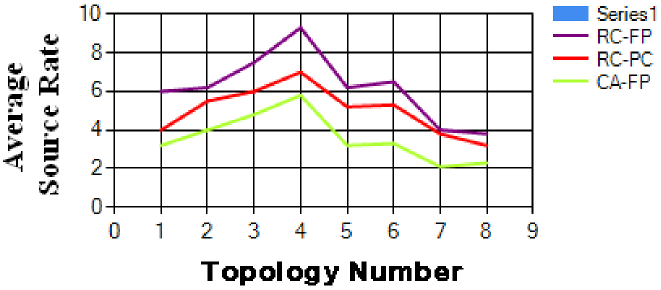


Fig 8: performance Of different resource allocation schemes: average source rates over 8 topologies

IX. CONCLUSION

In this paper, for wireless mesh network we have developed a resource allocation framework and Autonomous network reconfiguration system. The framework maximizes the aggregate utility of flows taking account the constraints that arises due to minimum rate requirement of sources and self-interference. The framework selectively drops a few of the sources if solution is not feasible and redistributes the resources among other in a way that their QoS requirements are met . Autonomous network Reconfiguration System (ARS) that enables a multi-radio WMN to autonomously recover from local link failures to preserve network performance. By using channel and radio diversities in WMNs, ARS generates necessary changes in local radio and channel assignments in order to recover from failures. The proposed framework readily leads to simple and effective admission control mechanism and lower local link failures, As compared with an optimal strategy we also theoretically compute performance bounds with our network.

REFERENCES

[1] S. Ahmed and A. Ramani, “Exploring the requirements for QoS in mobile ad hoc networks,” J. Inf. & Commun. Technol., vol. 1, no. 2, pp. 1–9, 2007.

[2] F. Kelly, “Charging and rate control for elastic traffic,” European Trans. Telecommun., vol. 8, pp. 33–37, 1997.

[3] X. Wang and K. Kar, “Cross-layer rate control for end-to-end proportional fairness in wireless networks with random access,” in 2000 ACM MobiHoc.

[4] 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.

[5] 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.

[6] 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.

[7] S. Low and D. Lapsley, “Optimization flow control—I: basic algorithm and convergence,” IEEE/ACM Trans. Networking, vol. 7, no. 6, pp. 861–874, 1999.

[8] H. Yaiche, R. Mazumdar, and C. Rosenberg, “A game theoretic framework for bandwidth allocation and pricing in broadband networks,”IEEE/ACM Trans. Networking, vol. 8, no. 5, pp. 667–678, 2000.

[9] S. Kunniyur and R. Srikant, “End-to-end congestion control schemes: utility functions, random losses and ECN marks,” in 2000 IEEE INFOCOM.

[10] X. Lin and N. B. Shroff, “The impact of imperfect scheduling on cross-layer congestion control in wireless networks,” IEEE/ACM Trans. Networking, vol. 14, no. 2, pp. 302–315, 2006.

[11] G. Sharma, R. R. Mazumdar, and N. B. Shroff, “Maximum weighted matching with interference constraints,” in 2006 IEEE International Workshop on Foundations and Algorithms for Wireless Networking.

[12] X. Wu and R. Srikant, “Regulated maximal matching: a distributed scheduling algorithm for multi-hop wireless networks with node exclusive spectrum sharing,” in 2005 IEEE CDC.

[13] P. Chaporkar, K. Kar, and S. Sarkar, “Throughput guarantees in maximal scheduling in wireless networks,” in 2005 Allerton Conference on Communication, Control and Computing.

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

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

[16] T. ElBatt and A. Ephremides, “Joint scheduling and power control for wireless ad hoc networks,” IEEE Trans. Wireless Commun., vol. 3, no. 1,pp. 74–85, 2004.

[17] A. Behzad and I. Bubin, “Optimum integrates link scheduling and power control for multihop wireless networks,” IEEE Trans. Veh. Technol.,vol. 56, no. 1, pp. 194–205, 2007.

[18] 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.

[19] A. Eryilmaz and R. Srikant, “Joint congestion control, routing and MAC for stability and fairness in wireless networks,” IEEE J. Sel. Areas Commun., vol. 24, no. 8, pp. 1514–1524, 2006.

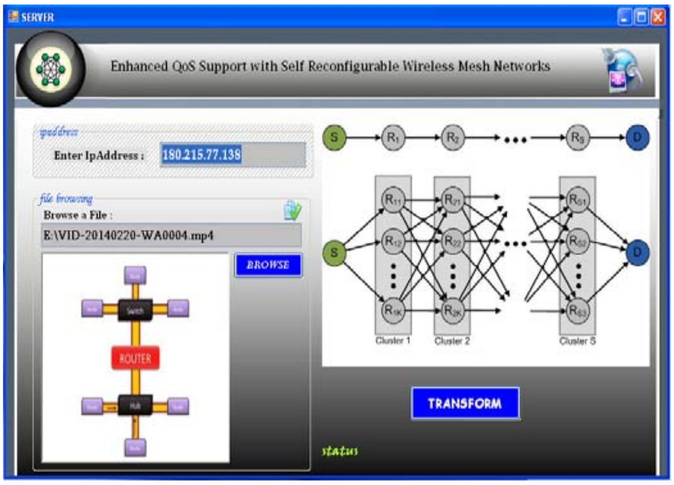
[20] P. Soldati, B. Johansson, and M. Johansson, “Proportionally fair allocation of end-to-end bandwidth in STDMA wireless networks,” in 2006 ACM MobiHoc.

[21] 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.

[22] M. Johansson and L. Xiao, “Scheduling, routing and power allocation for fairness in wireless networks,” in 2004 IEEE VTC.

[23] Tae-Suk, Yong Yang, Jennifer C, Fellow,IEEE, and Srikanth V. Krishnamurthy, Fellow,IEEE. “Resource Allocation For QOS Support In Wireless Mesh Network”

SNAPSHOTS



SERVER

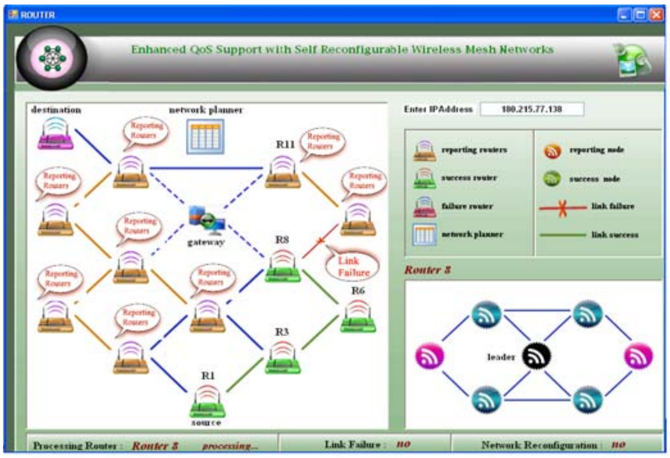
Enhanced QoS Support with Self Reconfigurable Wireless Mesh Networks

ipaddress

Enter IpAddress : 180.215.77.138

file browsing

Browse a File : E:\VID-20140220-WA0004.mp4



ROUTER

Enhanced QoS Support with Self Reconfigurable Wireless Mesh Networks

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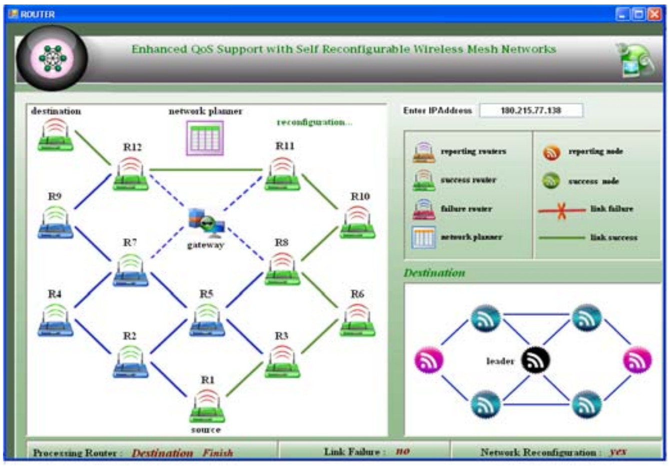
Router 8

Processing Router : Router 8 processing...

Link Failure : no

Network Reconfiguration : no



ROUTER

Enhanced QoS Support with Self Reconfigurable Wireless Mesh Networks

Enter IPAddress 180.215.77.138

reconfiguration...

Destination

Processing Router : Destination Finish

Link Failure : no

Network Reconfiguration : yes