Improved Autonomous Network Reconfiguration System

Aswathi.P, Lakshmi.K.S

Abstract— Wireless mesh networks (WMNs) are new developing technology in wireless networks and has a variety of applications. However during their life period, multi-hop wireless mesh networks which experience frequent link failures caused by channel interference from other collocated wireless networks, dynamic obstacles like Bluetooth, and/or application bandwidth demands .By this link failures the information transfer can be lost so the quality of communication cannot be achieved and cause severe performance degradation in WMNs. Sometimes for their permanent recovery, it requires expensive manual network management .This paper presents an *improved autonomous network reconfiguration system* (IARS) that enable a multi-radio WMN to autonomously recover from local link failure to preserve network performance. Based on current channel assignment and radio association, IARS first create some feasible local reconfiguration plans to recover from link failure. Next, based on that plans the system cooperatively reconfigures network setting among local mesh router. In addition, to strengthen WMNs performance, IARS decouples network reconfiguration from flow assignment and routing. In WMNs a threshold value is set for every node. When a node want to transmit data in the form of a packet from source to destination, it verify threshold value of each node, whether it reach its limit or not. When it reaches its limit, node choose another node to send data .It choose it route with minimum path cost value and minimum delay time, higher throughput. With this consideration, packet loss will be less when compared to ARS system.

Index Terms— ad-hoc networks, flow assignment and routing, Improved autonomous network reconfiguration system, link failures, Multi-radio wireless mesh networks, packet transmission, self-reconfigurable networks.
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1 INTRODUCTION

Wireless mesh networking (WMN) [1] is a developing technology that can be applied to provide cost effective wireless coverage in a large area. It is a special type of wireless ad-hoc network.WMNs dynamically self-organized and self-configured and made up of radio nodes organized in a mesh topology .So all nodes are connected to each other and each node send messages to other nodes. This feature brings many advantages to WMNs such as low-upfront cost, easy network maintenance, robustness, and reliable service coverage [1]. WMNs consist of two types of devices*: mesh router and mesh clients*. The mesh routers contain minimal mobility and it constitutes to form a backbone for the mesh clients. Mesh clients are often laptops, cell phones and other wireless device and can be worked as router, but it is much simpler than the mesh routers. So that the protocol used for communication can be used at lesser amount. So the chances of packet loss and link failure are more. Fig.1 shows the architecture of a wireless mesh network. A WMN can be presented as a 3-layered network organization with mesh clients at the bottom most layers, mesh router providing backend connectivity with distance locations and gateway for connecting with internet.
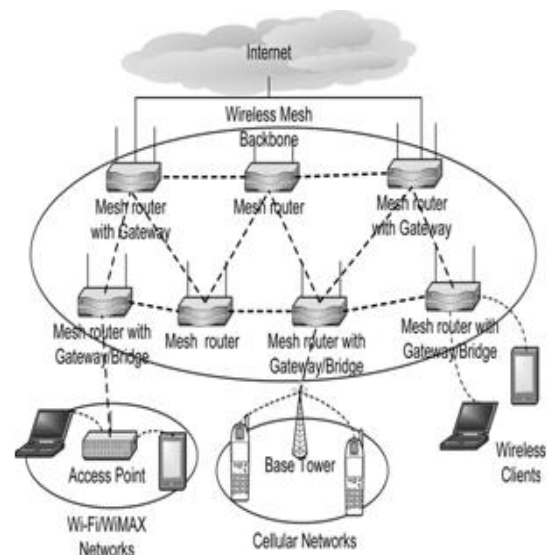
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- *Aswathi.p is currently pursuing masters degree program in network engineering in Mahatma Gandhi University,Kerala,India, PH-+919496366977. E-mail: p12aswathi34@mail.com*
- *Lakshmi K.S is currently working as assistant professor in Rajagiri School of Engineering and Technology,Kerala,India. E-mail: lakshmiks@rajagiritech.ac.in*

Fig.1.Architecture of a wireless mesh networks

Wireless mesh networks (WMNs) [2] has a variety of applications such as broadband home networking, community and neighborhood networks, enterprise networking, public safety, environment monitoring, and citywide wireless Internet services [1]. They can be also seen in other various forms to meet the increasing capacity demands. However, preserving the required performance of many WMNs have a challenging problem due its heterogeneity in node and fluctuating wireless link condition [2].For example, some WMN links might experience significant channel interference from other coexisting wireless networks. It is not possible for some parts of net-

works to meet increasing bandwidth demands from new mobile users. Links in a certain area (e.g., a hospital or a police station) might not be able to use some frequency channels because of spectrum etiquette or regulation [3].

Many solutions for WMNs to recover from wireless link failures and preserving the required performance have been proposed, but each of them have its own limitations.. One of the main solutions is resource-allocation algorithm [4], which requires "global" configuration changes. But in this paper we consider only the frequent link failures. Next solution is greedy-channel assignment algorithms [5], which consider only faulty links. However, it affects the settings of its neighboring nodes other than the faulty links. So the greedy assignment cannot reach its full improvements. Fault tolerant routing protocol [6],[7] is another solution, which rely on redundant transmission sand more network resource.

To overcome the limitations, we propose an *Improved autonomous network reconfiguration system* (IARS) that allows a multi-radio WMN (mr-WMN) to autonomously reconfigure its local network settings such as channel, radio, and route assignment for real time recovery from link failures. In its IARS is identifies feasible local configuration changes available around the faulty area, based on the current parameters like channel assignment and radio association for the recovery while minimizing changes of healthy network settings. Then, by imposing current network settings as constraints, IARS identifies reconfiguration plans that require the minimum number of changes for the healthy network settings. IARS also include a monitoring protocol. Running in every mesh node, the monitoring protocol periodically measures wireless link condition via a hybrid link-quality measurement technique [2]. Based on the measurement information, IARS detects link failures and/or generates QoS-aware network reconfiguration plans upon detection of link failures.

2 RELATED WORKS

The summary of various techniques used in recovering WMNs from link failures and maximizing the performance is presented in this section. And also include an overview of basic idea of each and every technique, their advantages and the associated limitations are given below.

Autonomous reconfiguration system (ARS) [2] is equipped with a planning algorithm. This algorithm provides autonomous reconfiguration to links to recover from link failures with the help of monitoring protocol. However it provides limitations such as higher delay, low throughput, considerable amount of packet loss etc.

Resource allocation algorithm [4] considers the problem of joint congestion control, channel allocation and scheduling for multi-hop wireless networks. The problem is solved by a dynamic algorithm and it is provides optimal solutions under certain assumptions. The algorithm provides holistic guidelines such as throughput bounds and schedulability for channel assignments during network deployment stage. But this algorithm requires global configuration changes which are a

difficult one while considering the frequent link failures.

Greedy channel assignment algorithms [5] can reduce the requirement of global network changes by changing settings of only the faulty links. It considers novel multi channel WMN architecture, specially tailored to multi hop wireless access network application. The greedy approach suffers from ripple effect, in which one local change affect the change of additional network settings. That is when we reconfigure the faulty links it may also affect the whole network nodes. But the strength of reconfiguration scheme depends on its availability to make the changes as local as possible. Only by considering configuration of neighboring mesh routers in addition to the faulty link, better performance could be achieved.

Fault tolerant routing protocol use local rerouting [6] or multipath routing [7]. So the failure links are avoided by path diversity. In the multipath routing scheme the ticket based probing is employed. These ticket based probing provides a ticket which is used to search one path. These tickets are given by the source node. It is based on the state information only. Suppose if there is tighter requirements in connection, then more number of tickets will be given. Then the probing, it is also considered as routing messages. These routing messages are being transmitted from the source node to the destination in order to find the least cost path. These routing messages should at least carry one ticket regularly. This ticket based probing provides some advantages, routing overhead is controlled based on number of tickets, and it uses stationary links when there is any requirement ,so by using these stationary links the path will be more stable.

Interference aware channel assignment [8] method for multi radio wireless mesh networks that addresses interference problem. Their system intelligently assigns channels to radios providing minimal interference within the mesh network and between the mesh networks and co-located wireless networks. It deploys a novel interference estimation technique that can be implemented at each mesh router. The basis for the method is the idea of multi radio conflict graph, used to model the interference between the routers. The major issue associated with this approach is that it can only improve overall network capacity by using additional channels. It does not take in to account together both the essential aspect namely link association and local traffic information.

EAR algorithm [9] focus on maximizes the measurement accuracy. It uses three complementary measurement schemes: Passive, cooperative and active monitoring.EAR effectively identifies the existence of wireless link asymmetric by measuring the quality of each link in both direction of the link.

Joint channel assignment routing and scheduling problem [9] that can be model the interference and fairness constraints and is also able to account for the number of radios at each of the wireless nodes. A novel flow transformations technique to design an efficient channel assignment algorithm that can assign channels to nodes radios while ensuring that maximum data can be transmitted on specified traffic routers.

3 PROPOSED WORK

3.1 Overview

Multi-radio WMN: A network consists of mesh nodes-mesh router and mesh clients, IEEE 802.11 based wireless links, and one control gateway. Fig.2. shows a multi-radio WMN. Each mesh node is equipped with *n* radios, and each radio's channel and link assignments are initially made by using global channel/link assignment algorithms. 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.
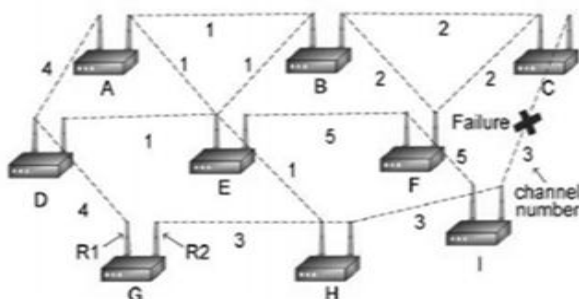
Fig.2. Multi-radio WMN.A WMN has an initial assignment of frequency channels as shown. [2]

*Flow admission using QoS value :*During its operation ,each mesh node in WMNs periodically send its local change usage and the quality information for all outgoing links to the control gateway via a management messages. Then, based on this information, the gateway controls the admission of requests for voice or video flows. For admitted flows, the information about QoS requirements is delivered to the corresponding nodes for resource reservation trough the RSVP protocol [10]. RSVP mechanism provides a general facility for creating and maintaining distributed reservation state across a mesh of multicast or unicast delivery paths. RSVP is simplex, i.e., it makes reservation for unidirectional data flows. RSVP is receiver-oriented, i.e., the receiver of the data flow initiates and maintains the resource reservation used for that flow. Next, the network runs routing protocols such as WCETT [2] or ETX [2] to determine the path of the admitted flows. This routing protocol is also assumed to include route discovery and recovery algorithms that can be used for maintaining alternative path even in the presence of link failures.

3.2 Features of IARS

1) Localized reconfiguration: IARS generates reconfiguration plans to recover from link failures. Those allow for changes of network configurations only in the faulty area and do not change all the network settings. That it is made changes as local as possible.
2) QoS-aware planning: By estimating the QoS-satisfiability

of generated reconfiguration plans and deriving their expected benefits in channel utilization, IARS efficiently identifies QoS satisfiable reconfiguration plans.
3) Autonomous reconfiguration through link-quality monitoring: Based on the measurements and given link's QoS constraints, IARS detects local link failures and autonomously initiates network reconfiguration.
4) Cross-layer interaction: IARS actively interacts across the network and link layers for planning. This interaction enables IARS to include a re-routing for reconfiguration planning in addition to link-layer reconfiguration.

3.3 Modules in IARS

1. Network construction
2. Path estimation
3. Packet transmission
4. Failure detection
5. Autonomous reconfiguration planning

Network construction: To send data from source node to destination node, generate wireless network according to the mesh topology. Network has the node details and also maintains the connection details. Nodes are connected with other nodes via different links and exchange the information directly with other nodes in the network .Network server maintains the node ip address, port details and status. Node give request to server and get the node details from server.

Path estimation: send sender node request to receiver node a through all possible paths when connection established, and receive the response from receiver. We measure the available route by getting details from server system. For each available path calculate the path cost. Also measure the delay time for each available path from sender node to destination node. And find the minimum delay time and minimum path cost from the source node to destination node. It measures the throughput for each available route from source node to destination node. We send the date to receive node among these path.

Packet transmissions: Once a path is identified from source node to sink node. The packet transmission starts from source to destination. Generally, data in networks is transmitted in packets. A packet is small piece of data. Packet consists of data and size of data varies which is to be transmitted over network. One of the reasons to make use of packet is safe and secured transmission of data.

IARS decouples network reconfiguration from flow assignment and routing. Reconfiguration might be able to achieve better performance if two problems are jointly considered. In this, a *threshold value* is set for every node.Fig.3.shows the flow chart of packet transmission in IARS.
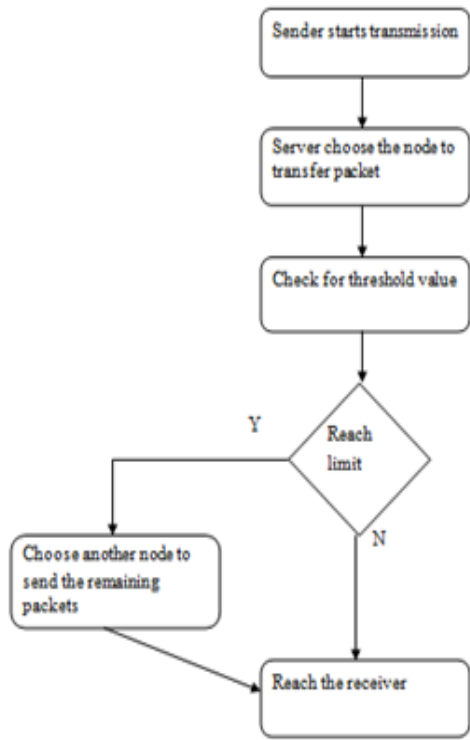
Fig.3. flow chart of packet transmission in IARS

Before sending the data, sender node will calculate threshold limit, because it is used to avoid the node failure of the sending data. While the data is send through that shortest path, it checks for the threshold limit. If the threshold limit exceeds, it alternatively select another path that does not have any repeated nodes which was available in the previous path. Trough this available path, the data from source node to destination node is sent. That path provides minimum path cost value and minimum delay time and decrease the packet loss.

Failure detection: Due to link failure the packet dropping occurs. These packet losses occurred not only for link failure even they occur if the traffic exhibits some congestion. Failure detection plays a significant role in the designed autonomous WMN. For failure detection link monitoring is used. Monitoring is an important phenomenon when we consider the link failure. Generally monitoring is the basic operation involved in many link recovery algorithms. Every node monitors the quality of its outgoing wireless links. For that a *monitoring period* is used. Since we use a mesh network, all nodes has connectivity to all other nodes. This connectivity can be ensured by transmitting test messages to all the nodes from source node. The node contains information about the incoming and outgoing traffic. It maintains the information about the neighboring nodes. It measures wireless link condition via a hybrid link quality measurement technique. So we can easily

identify the link failure.

Once the node get failed autonomous system identifies failures accordingly generates reconfiguration plans. Among the generated plans one of the best plans will be selected with less number of changes in the network.

Autonomously reconfiguration planning: IARS is a distributed system that can be easily implemented in IEEE 802.11-based mr-WMNs.IARS in every mesh node monitors the quality its outgoing wireless links at every monitoring period. Using a management message, node reports the result to a gateway. Second, once it find a link failure(s), IARS in the detector node(s) triggers the formation of group among local mesh routers that use a faulty channel, and one of the group members is elected as leader depending on their energy (e.g.battery life of mobile phones).

Energy check: Energy is considered to be the important phenomenon. Generally required energy will be more, when the distance became large and also if the high resources are used .In this paper, the energy is calculated for the neighboring nodes from the link failure occurred node. Then the node with highest energy is elected as a leader.

Third, the leader node sends a planning request message to the gateway. Then, the gateway synchronizes the planning requests, if there are multiple requests then generate a best reconfiguration plan for the request. Fourth, the reconfiguration plan is send by the gateway 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 reconfiguration stage, all messages are reliably delivered through a routing protocol and per-hop transmission timer. Fig.4. shows the software architecture of IARS.
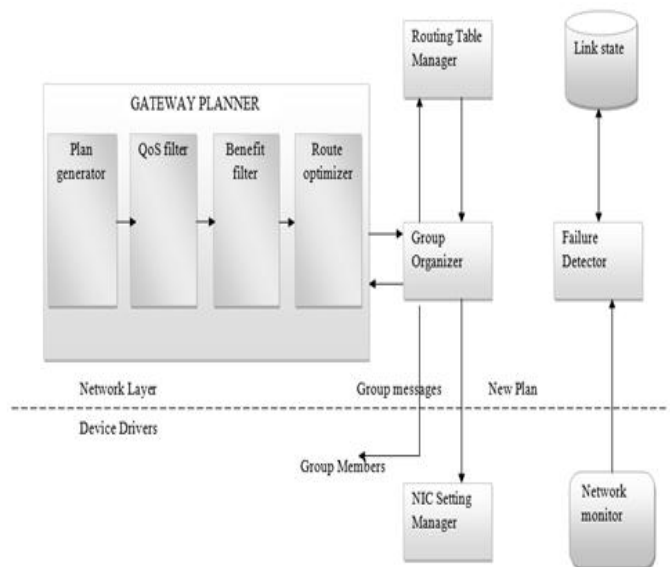

Fig.4. Software architecture of IARS.

IARS has A) a plan generator. It includes:

1. *Gateway planner*: A gateway planner has the following parts.

   1.1 *network planer*: It generates reconfiguration plans only in gateway.

   1.2. QoS *planner*: IARS applies strict constraint to identify a reconfiguration plan that satisfies the QoS demands and that improves network utilization most

   1.3. *Benefit filter:* It identifies which reconfiguration plans are suitable to reach destination.

   1.4. *Optimal*: It identifies, which reconfiguration plan having shortest path to reach destination .Identifies reconfiguration plans that require the minimum number of changes for the healthy network settings.

B) *Group organizer*: Forms a local group among mesh routers.Fig.5 shows the diagrammatic representation of group organizer.
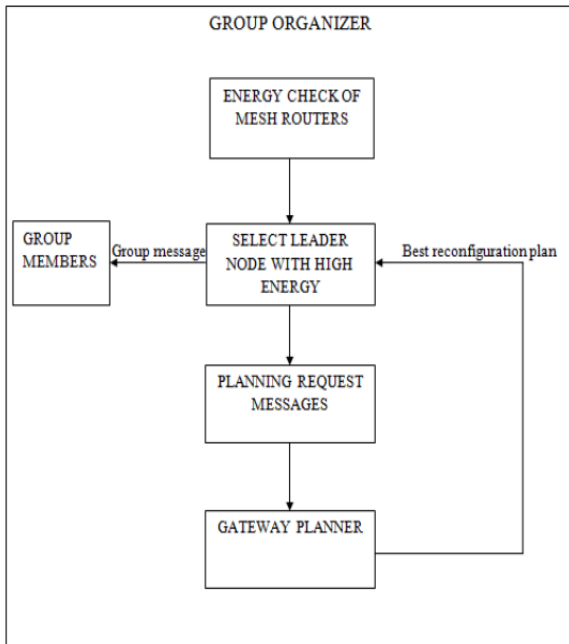

Fig.5. diagrammatic representation of group organizer.

C) *Routing table manager*: IARS updates states of a system routing table.

   The operation of IARS described in details in the following section.

   The core function of IARS is to systematically generate localized reconfiguration plans. A reconfiguration plan is defined as a set of link's configuration changes (e.g., channel switch, link association) necessary for a network to recover from link(s) failure on the channel. IARS systematically generates reconfiguration plans that localize network changes by dividing the reconfiguration planning into three processes: feasibility, QoS satisfiability, and optimality and applying different levels of constraints [2].Fig.6.shows the three processes
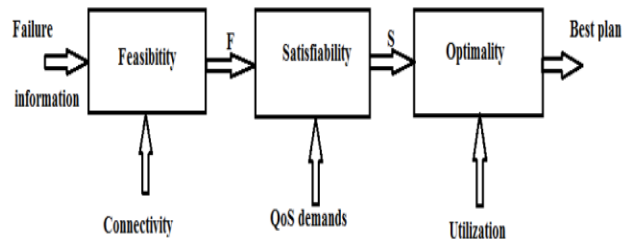
of IARS.

Fig.6.shows three processes in IARS

Feasible plan generation: In the process IARS generate all possible feasible plans denoted as *F*. Given multiple radios, channels, and routers, IARS identifies feasible changes that help avoid a local link failure but maintain existing network connectivity as much as possible.Fig.6.shows the diagrammatic representation of feasible plan generation. Feasible plan generation *avoid faulty channel* through three primitive link changes as explained in table 1.Specifically ,to fix a faulty link ,IARS can use:1)a channel –switch S where both end-radios of link AB can simultaneously change their tuned channel;2):a radio-switch R where one radio in node A can switch its channel and associate with another radio in node B;and3)a route-switch D where all traffic over the faulty link can use a detour path instead of the faulty link.

TABLE1
Definition of link-change in IARS.

Primitive changes	Description
Channel switch(S(Ai,Bj))	Radios Ai and Bj of link AB switch their channel to other channel.
Radio switch(R(Ai,Bj))	Radio Ai in node A re-associates with radio Bj in node B, tuned in a channel.
Detouring(D(Ai,Bj))	Both radios Ai and Bj of link AB remove their associations and use a detour path, if exists.

It maintains network *connectivity and utilization*, for which IARS takes two –step approach. IARS first generate feasible changes of each link using the primitives, and then combines a set of feasible changes that enable a network to maintain its own connectivity. Furthermore, for the combination, IARS maximizes the usage of network resource by making each radio of a mesh node associate itself with at least one link and by avoiding the use of same channel among radios in one node.

Controlling the scope of reconfiguration changes: IARS uses *k*-hop reconfiguration parameter. Starting from a faulty link, IARS considers link changes within the first k hops and generates

feasible plans. If IARS cannot find a local solution, it increases the number of hops *(k)* so that IARS may explore a broad range of link changes. Thus, the total number of reconfiguration changes is determined on the basis of existing configurations around the faulty area as well as the value of *k*.
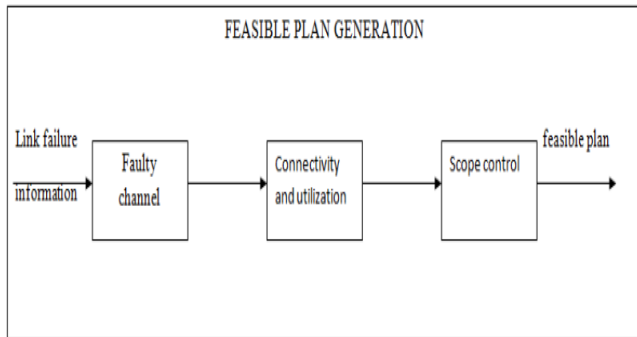

Fig.6.Feasible plan generation

QoS-Satisfiability Evaluation: Among a set of feasible plans *F*, IARS now needs to identify QoS-satisfying reconfiguration plans by checking if the QoS constraints are met under each plan. For that per-link *bandwidth estimation* and also examine per-link *bandwidth satisfiability*. For that it use link's *busy airtime ratio* (BAR) can be defined as BAR=q/C, where q is a link's bandwidth requirement and C is link's capacity and BAR must not exceed1.0 (i.e., BAR<1.0) for a link to satisfy its bandwidth requirement. If multiple links share the airtime of one channel, IARS calculate aggregation BAR aBAR of end radios of a link, which is defined as aBAR(k)=$\sum_{l \in L(k)} (ql/Cl)$,where k is a radio ID,*l* a link associated with radio k,and L(k)the set of directed links within and across radio k's transmission range. It also avoid the cascaded link failures.Fig.7 shows the diagrammatic representation of QoS-satisfiability evaluation.
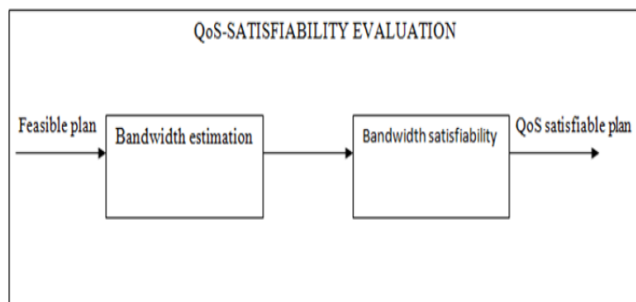

Fig.7. QoS-satisfiability evaluation

Optimality: In the stage IARS choose the best plan from the set of reconfiguration plans that are QoS-satisfiable and needs to choose a plan within the set for a local network to have evenly distributed link capacity. For that IARS use benefit filter to choose the beat plan.

4 CONCLUSION

This paper presented an Improved network reconfiguration system (IARS) that enables a multi-radio WMN to autonomously recover from wireless link failures. IARS generate a feasible reconfiguration plan that require only local network configuration changes and satisfy application QoS constraints by exploiting channel, radio, and path diversity. Also IARS decouples network reconfiguration from flow assignment and routing. Reconfiguration might be able to achieve better performance if two problems are jointly considered. With this consideration, some considerable amount of packet loss will be less when compared to the ARS system. IARS also help to decrease the delay, higher the throughput during the packet transmission.

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