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Design of ARS for wireless mesh network using Network Simulator

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***Abstract*— Wireless mesh network (WMN) offers many applications such as public safety, environment monitoring and city wide wireless internet services. There are however, WMN may encounters huge channel interference from other coinciding wireless network, which brings about link breakage bringing on low in performance that obliges expensive network management for their recuperation. We propose a novel Autonomous reconfiguration system namely ARS. The basic scheme is that it autonomously reconfigures and recovers from local link failures. By using NS2 simulation ARS has been evaluated and implemented. ARS enhances channel efficiency and throughput. We also present an enhanced scheme which combines the basic scheme with dynamic network in which nodes are in mobile condition.**

***Index Terms*— ARS, link failure, failure detection, route recovery, reconfiguration, improvement of channel efficiency, IEEE 802.11.**

I. INTRODUCTION

In recent year wireless communication is most widely used, so the wireless mesh networks (WMN) are built on a combination of fixed and mobile nodes interconnected via wireless links to form a WMN that consists of mesh routers and mesh clients.WMN has some important characteristics such as wireless network which expands the coverage range of current wireless network and non line of sight (LOS) connectivity among the users, support for adhoc networking and capability of self forming- self healing- self organisation, mobility dependence on the type of mesh nodes, multiple types of network access, dependence of power consumption constraints on type of mesh nodes, wireless infrastructure/backbone provides robustness. Mesh routers have minimal mobility and form backbone of WMN; they provide network access for both mesh and conventional clients. Mesh clients can be either stationary or mobile and can form a client mesh network among them. The WMN enhances connectivity of users directly with each other and provides multiple paths to network for communication and centrally located towers are not necessary. By using different signal paths they can bypass different obstacles such as hills, tresses, buildings have no any breakages in link and can easily pullout. WMN will deliver wireless services for a large variety of applications in personal, local, campus and metropolitan areas. Some of the applications are broadband home networking, community and neighbourhood networking, enterprise networking, metropolitan area networking, transportation system, building automation, health and medical system, security surveillance system. Recent advances in WMN, many research challenges remain in all protocol layers.

WMN has some challenging problems to meet necessary performance of the system due to traffic in network and channel interference because of these some links of WMN gets damaged or affected or failed to transfer data from source to destination and some part of the networks does not meet bandwidth requirement from other users. For example, some links of a network may experience significant channel interference from other co existing wireless networks. Some portion of networking might not be able to meet highest bandwidth demands from new mobility users and applications. Links in certain areas such as hospital may not able to use some frequency channel because of spectrums etiquette or regulation.

Many approaches have been proposed to recover wireless link breakage in wireless networks, but they still have several limitations. First approach is resource allocation algorithm, it provide theoretical guidelines for initial network resource planning and also they provide a comprehensive and optimal network configuration plan, they often require “global” configuration changes, which are undesirable in case of frequent local link failures. Second, fault tolerant routing protocols, such as multipath routing or local rerouting, can be adopted to use network level path diversity for avoiding faulty links. But, they rely on detour path or redundant transmission, which requires more network resources than link level network reconfiguration. Third, a greedy

channel assignment algorithm, this approach can reduce the requirement of network resources (changes) by changing settings of faulty link.
To overcome these limitations, we propose a new approach, an autonomous network reconfiguration system (ARS). ARS is that autonomously recover and reconfigure its local network settings (channel, radio and route assignment) for real time recovery from link failures in WMN. ARS also enhance the performance of network by improving network throughput and channel efficiency over rerouting and greedy channel approaches.

II. RELATED WORK

On the various problems in wireless mesh network, up till now lots of work has been done. By the use of planning algorithm which helps to the local changes as possible instead of changing the entire network arrangement. The algorithm often requires global changes in network, the QoS on each link must have to satisfy as possible. The approximately maximum network configuration can be provided by scheduling algorithm, bandwidth constraint and channel assignment. To maximize the chance of getting QoS demand configuration algorithm requires only local changes. Among multiple network layer network setting can be consider by network configuration. The local rerouting allow for flow reconfiguration to get QoS constraint by exploiting path diversity, more network resources consume by them than link reconfiguration because of redundant transmission. To neglect extra QoS failure of adjacent nodes the channel, link assignment within the network and I ink layer etc. have to take interference into account.

III. ARS ARCHITECTURE

ARS support re-configurability because of following specific features.

A. *Summary*

- *QoS aware planning:* ARS recognizes the QoS satisfiablity of organized reconfiguration plans. In channel utilization generating their expected profits.
- *Link quality monitoring:* In the distributed manner autonomous reconfiguration system examines quality of each node. Depending on link's QoS constraint and calculation, autonomously reconfiguration system identifies local link failure and initiates the network reconfiguration autonomously.
- *Link layer interaction:* For the purpose of planning autonomously reconfigurable system interact within the network and link layer; it causes to include rerouting in addition to link layer configuration.
- *Contained Reconfiguration:* By generating recon figuration plan ARS permits for changes of reconfiguration of network where link failure occurred maintaining configuration in space away from failure location.
- *By monitoring link quality Autonomous reconfiguration:* In distributed manner ARS check the quality of every node, depending on link's QoS constraints and measurement, ARS identifies failure and network reconfiguration autonomously initiates.

B.ARS Flow Chart

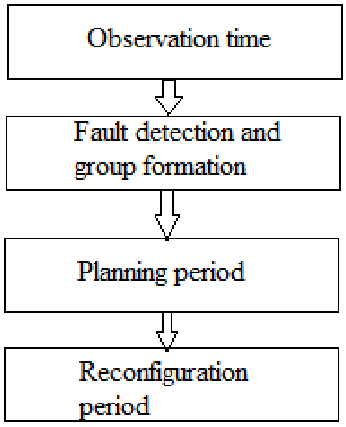


Fig.1. Flowchart of ARS

The above flow chart describe the operation of autonomously reconfigurable system, first it at every time i.e. at 10 s observe the quality of wireless link and via management message, send result to gateway, after detecting the link failure trigger the formation of group, one of the group member selected as leader. The planning request is sent by leader node to gateway, then gateway generate reconfiguration plan for request, if there are multiple request. Reconfiguration plan send to the group member and leader node by gateway. All nodes in group execute the changes. Routing protocols send all the messages during formation and reconfiguration.

C. Network Reconfiguration Planning

ARS generate reconfiguration plan for every failure of link, different network configuration can be caused due to changes in link requirements, ARS applies connectivity constraint to create group of feasible reconfiguration plan to enumerate link, channel, route changes around the faulty region, given link failure constraint and connectivity. To identify plan of reconfiguration, this satisfies QoS demand and improves network utilization.

- *Plan Generation:* To avoid local link failure and maintain existing network connectivity ARS identifies some

Main changes	Working
Channel switch (S(Xi,Yj)o >σ)	Radios Xi and Yj of link XY switch their channel(o) to other channel(σ)
Radio switch (R(Xi,Yj)o >σ)	Radio Xi in node X reassociates with radio Yj in node y ,turned in channel(σ)
Detouring (D(Xi,Yj))	Both radios Xi and Yj of link XY remove their association and use detour path

Table 1: Many changes can be used to represent the changes of multiple links

- *Removing faulty channel:* ARS identifies three main link changes for fix faulty link.1) ARS can use both the end radios of link XY can simultaneously change their tuned channel i.e. channel switch S.2) A radio switch R where one radio in node X can switch its channel and associate with another radio in node y.3) A route switch L, instead of using faulty link all traffic over faulty link use detour path.
- *Network connectivity maintenance and utilization:* To avoid the use of faulty channel, it is necessary for ARS to maintain connectivity with radio resources full utilization. With multiple neighbouring nodes, each radio is associated, so change in one link causes neighbouring link to change their settings. ARS takes two-step approaches 1) ARS combines set of feasible changes that enable a network to maintain its own connectivity. The usages of network resources are maximized by ARS by making each radio of a mesh node, avoiding the use of same channel among radios in one node.

D. Maintaining the scope of reconfiguration changes

As local as possible, ARS has to limit local changes, at the same time by considering more network changes or scope it need to find locally optimal solution. ARS uses k-hop reconfiguration parameter. ARS assumes in first k hop some link changes and creates feasible plan. ARS cannot find local solution, it increases quantity of hop so that, it may explore broad range of link changes. On the basis of existing reconfiguration for the faulty and value of k, total reconfiguration is defined.

IV. IMPLEMENTATION

A. ARS Implementation Detail

changes, but doing this ARS has to address the following challenges.

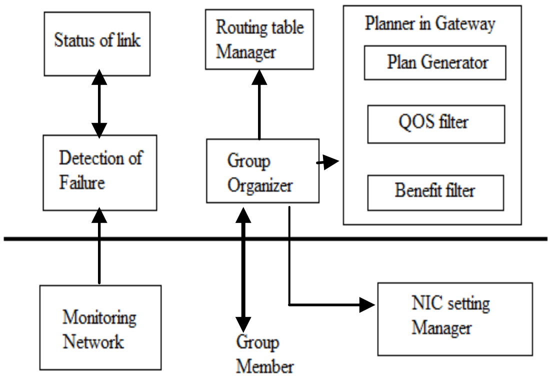


Fig.2. ARS Software Architecture

Fig. 2 shows ARS software architecture. In the network layer using netfilter, inside the Linux kernel netfilter is set of hook which permits the kernel modules to register the function of callback with the stack network. For every packet that traverses the respective hook within the network stack a registered callback function is then called back. For the definition of rule sets IP table is generic table structure. Within an IP table each rule consists of one connected action (IP table's target), connection tracking, number of classifiers, ip tables. The major part of framework is built by the NAT subsystem together [9].

ARS is implemented which provides ARS with hook to detent and send formation of group messages. This module include in network layer

1. *Link Status:* In which it identify the status of link, whether link is failed to send data or working properly.
2. *Failure detector:* It detect the failure if occurs while sending data.
3. *Group Organizer:* This generates group between different mesh routers.
4. *Routing table manager*: Routing information is provided by routing table manager to all interested client such as management programs, routing programs, and routing protocols. It passes best information to the entire interested client. Through routing table manager ARS can be obtained.

For making accurate network monitoring in MAC layer the device driver allows for accessing management registers and various control. The device driver includes

1. *Monitoring Network:* Network monitor constantly the network for slow and failing components. In case of outages that notifies network administration. Monitor the network which includes different links and nodes.
2. *NIC setting manager*: Based on reconfiguration plan from group

organizer, NIC setting is reconfigured efficiently.

B. Setup of Experiment

The test bed consist of several mesh node and in between there are multiple links. In order to receive and send strong signal from and to adjacent nodes, each node is placed on high level rate and transmission. For wireless interfaces and implementation of ARS, all nodes run Linux OS, MADWiFi device driver [8]. For routing protocols weighted cumulative expected transmission time (WCETT) and ETX [10] routing matrices are implemented. The WCETT include assigning weight to every link given time in transmission linked out. WCETT has a routing metrics that take two things into account 1) Channel assignment diversity 2) Difference in the bandwidth of link. It has advantage to configure the best path for the variety of channel offered and bandwidth of link IGWs.

V. TEST RESULTS

ARS causes the improvement in quality of system satisfiability, efficiency of channel, and throughput, ripple effect reduction.

1. *QoS gain satisfaction*: QoS indicate differentiation of traffic and using multiple point to point communication service between two networks with significances and configuration adjusted to guarantee sufficient service quality of each user. Based on QoS classes identifiers network controlled simplified QoS profiler and network initiated bearer establishment are vital features of the evolved QoS concept. ARS generally is responsible for getting varying QoS demand. To show the gain considers the example as follows.

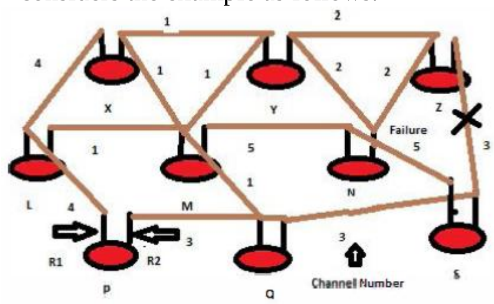


Fig.3. Multiradio WMN undergoes wireless link failure and requires reconfiguring its setting.

Where the node X, Z and P are the gateway, a mesh router in the shop and mesh router in a control room respectively. During meeting through router Z mobile clients in the shop request video stream and after meeting return to the control room and connect to the router P. It can measure the total number of admitted stream after network reconfiguration, while number of video stream increases. ARS improves chance for wireless mesh network to meet varying QoS demand.

2. *Rejection of ripple effect:* ARS helps in rejecting ripple effect of network reconfiguration. To induce the failure on different link, run the same scenarios with two interference frequency (i.e. 5.28 and 5.2 GHz). For comparison the three failure recovery methods are used i.e. local rerouting, greedy, ARS. As shown in figure, with each of three recovery scheme the average throughput performance improves. But by using ARS reconfiguration methods throughput performance increases more as compare to other methods. According to planning algorithm to another channel ARS switches the fault related channel link. Local rerouting can causes interference of channel heavily for the detour path, slows down the neighbouring flow's activity.

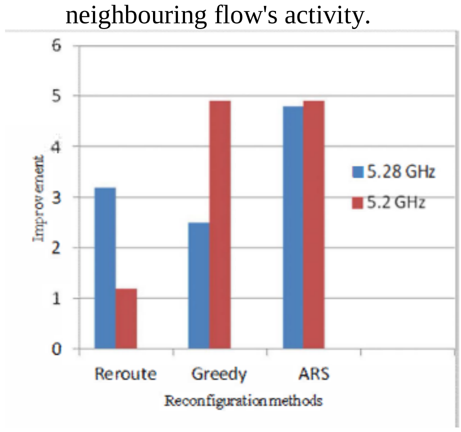
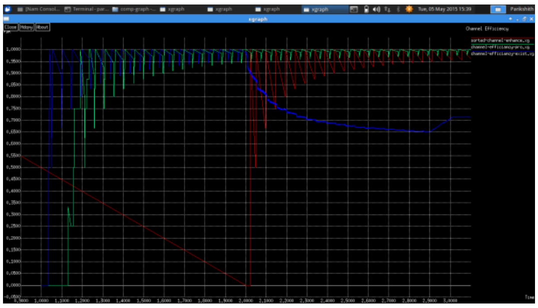


Fig.4. By each reconfiguration methods improvement from the degraded throughput

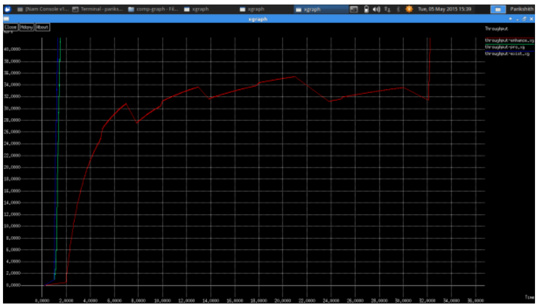
3. *Channel efficiency and Throughput gain:* In this paper one UDP flows at maximum rate for selected link on the test board increasing the level of interference, as shown in graph static assignment causes the severe degradation of throughput, but ARS detect failure using completes network reconfiguration and link quality monitoring information. The delay is mainly to link quality information update and with gateway a communication delay and the delay can be adjusted. Actual channel switch is less than 3 ms. causes negligible flow disruption. The local rerouting improves the throughput using detour path, still suffers from throughput degradation because of along detour path an

increased loss rate.



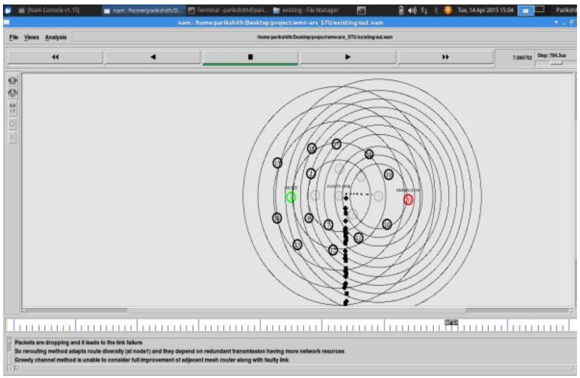
a)

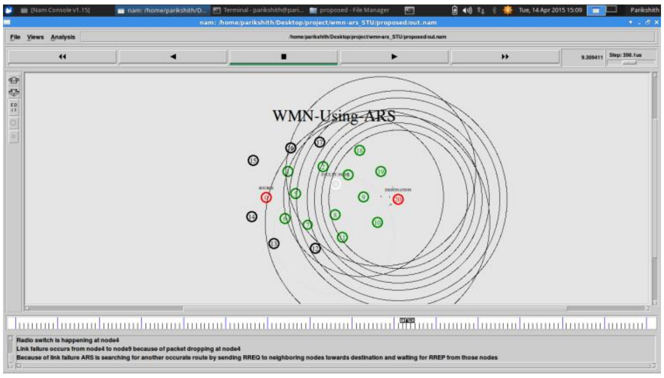
Over the other recovery methods ARS also improves channel efficiency. The static channel assignment suffers very less channel utilization due to frame retransmission on failure channel. Static channel assignment has some limitation but by using ARS that limitation can overcome.



(b)

Fig.5. Gain in throughput and channel efficiency (a) Channel-efficiency gains. (b)Throughput gains





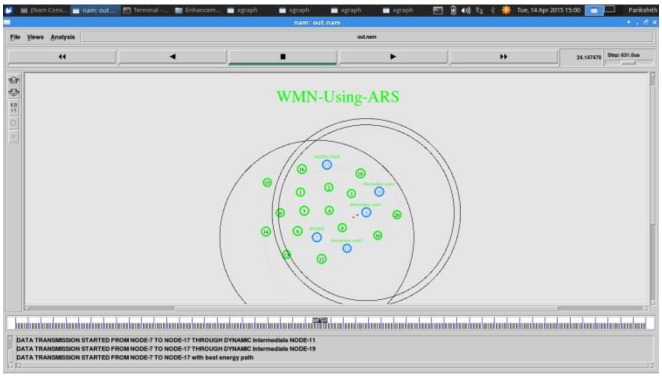


Fig.6. NAM Window showing data transfer of Existing, Proposed and Enhanced methods

As NS2 is used, this provides output in two forms i.e. X-Graph and NAM window. The above are the X-Graph showing the throughput and channel efficiency improvement. NAM window shows animation of how data transfer from source to destination .Total 21 nodes are generated, node 0 is source node, node 8 is destination node, while transferring the data from source node to destination node, it select shortest path, but if in case link or node failure occurs then radio switch and channel switch done by ARS, another alternative shortest path is selected. As shown in NAM window node 4 is failed, so that data reach to the destination by choosing another path which comes in broadcasting range node in network. Meanwhile ARS detect failure in the network, reconfigure it and recover it. After reconfiguration again the first shortest path is selected. By doing this it helps to reduce loss of packets transfer, enhance channel efficiency and throughput. In existing and proposed method the nodes are immobile but in enhancement nodes are free to move anywhere and communicate with other nodes which are in broadcasting range ie, dynamic ADHOC network is implemented.

VI. CONCLUSION

ARS autonomously reconfigure failure in the network by generating effective reconfiguration plan which satisfy application's constraints and admitting up to two times more flow than static assignment. Based on existing MAC, routing, and transport protocols, network performance is not scalable with either the number of nodes or the number of hops in the network and also the nodes are in mobile condition.

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