Link Failure Recovery using Autonomous Network Reconfiguration System in Wireless Mesh Networks

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***Abstract*— Wireless mesh networks (WMNs) are part of ad-hoc networks which are characterized by self-organized and self-configured property. However due to some channel interference it shows some frequent link failures. This paper presents autonomous network reconfiguration protocol (ARS) which enables multi-radio WMN to autonomously recover from the link failures. It equipped with a reconfiguration planning algorithm. This help to find a new path with minimum delay and path cost. ARS protocol is then compared with AODV protocol using different QoS factors. ARS protocol has been evaluated through ns-2 based simulation which provides better performance than AODV protocol.**

Keywords-IEEE 802.11, Multi-radio WMNs, Self-reconfigurable networks, Wireless link failures, Wireless mesh networks.

I. INTRODUCTION

Wireless mesh networks (WMNs)are developed and deployed very quickly in new era[1].It has many application in the real life such as public security and safety, monitoring of environment and citywide wireless internet services[1]-[3].It has two devices: mesh clients and mesh router. Mesh clients may be laptop, cell phones etc. It can also act as a router. Mesh routers have minimum mobility and provide a backbone for mesh clients. Wireless mesh networks can be organized in a three layered structure. Mesh clients are in the bottom level, mesh routers in the middle, provide backend connectivity and gateway which is used to connect the internet form the top level.Fig.1 shows the architecture of WMNs.

However due to some interference from other collocated channel and fluctuating link conditions WMNs may shows frequent link failures[4]-[5].This affect its performance. So a real-time recovery from link failures requires expensive manual network management. Many existing solutions are there. But each one has its own limitations. Greedy-channel assignment algorithm [6] changes only the faulty links .But it produce some ripple effects. Resource-allocation algorithms [7] provide guidelines for initial network resource planning. So it require global configuration which cannot be applicable to local link failures. Fault-tolerant routing protocol like local rerouting [8] and multipath routing[9] can be used to avoid faulty links ,but it require more network resources. So here propose an autonomous network reconfiguration system (ARS) to recover from link failures. That enables a multi-radio WMN (mr-WMN) [10] to autonomously reconfigure from local link failures. It mainly changes the local network settings of channel, radio and route assignment. ARS is equipped with a reconfiguration planning algorithm which search only local feasible configuration changes and not affects the whole network settings.

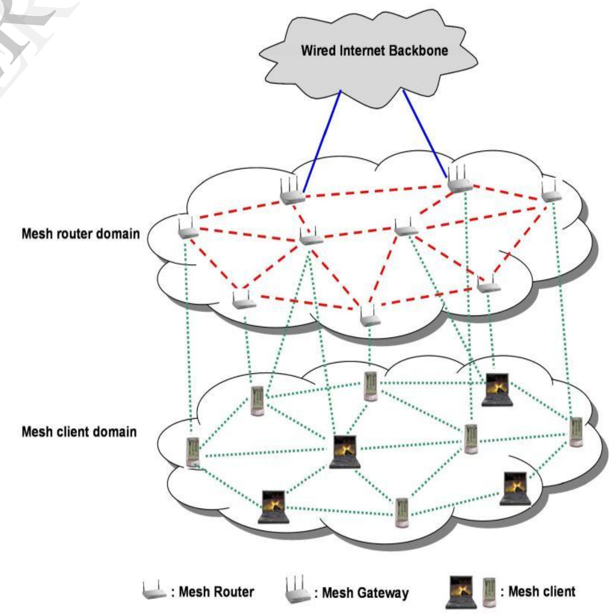

Fig.1.Architecutre of WMN

In the rest of the paper, Section 2 discusses related work. Section 3 explains the ARS architecture. Section 4 show simulation results of ARS. Section 5 concludes the paper.

II. RELATED WORK

The summary of various techniques used in recovering WMNs from link failures are 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 network reconfiguration system (ARS) [10] used to recover from local link failures using a reconfiguration planning algorithm. This is also used a monitoring protocol for monitoring the outgoing wireless link conditions. However the packet loss and delay is very high in ARS system.

Resource allocation algorithm [7] deals with joint congestion control, channel allocation and scheduling in multi-hop multi-radio wireless networks. The problem is formulated as a joint optimization and solved it by using dynamic algorithm and provides optimal solutions under certain assumptions. It jointly define congestion control, routing, channel loading and interface binding and scheduling. Here using the notation of virtual links to facilitate analysis of multi-channel networks. The algorithm provides guidelines during network deployment stage. But this algorithm requires global configuration changes which are difficult when we considering the frequent link failures.

Greedy channel assignment algorithm [6] changing the settings of only the faulty links so it can reduce the requirement of global network changes. It considers multi-hop multi-radio wireless networks. The greedy algorithm suffers from ripple effects, in which one local change affect the change of additional network settings. Only by considering configuration of neighboring mesh routers in addition to the faulty link, better performance could be achieved.

Fault tolerant routing protocol such as local rerouting [8] or multipath routing [9] uses path diversity to avoid link failures. To search a path a ticket based probing is used in multipath routing. Based on the state information the tickets are given by the source node. If there are tighter requirements in connection, then more numbers of tickets will be given. Then to find a least path from source node to destination node routing message is sent. Each routing message contains tickets. It has 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.

Enhanced reconfiguration system [11] provide cost aware reconfiguration scheme to recover from link failures in wireless mesh networks. It generates a set of reconfiguration plans and selects the best plan which provides the required services at minimum cost. Cost analyzer calculates the total reconfiguration cost associated with each and every plan generated.

III. PROPOSED SYSTEM

A) Link Failures in Wireless Mesh Networks

Here we consider three types of link failures. They are:

1. Link quality failures
2. QoS failures
3. Spectrum failures

A link quality failure [10] occurs when the quality of wireless links in WMNs is degrading due to severe interference from other collocated wireless networks.

Links in some area may not be able to accommodate increasing QoS demands from end-users depending on spatial or temporal locality called QoS failures [10].

A spectrum failure [10] occurs when links in some areas may not be able to access wireless channels during a certain time period due to spectrum etiquette or regulation [12].

Here consider only channel related link failures and not focus on hardware failures.

B) ARS Structure and Features

1) ARS structure

We have a network with mesh nodes, IEEE 802.11-based wireless links and one control gateway. Each mesh node has n number of nodes and the radio's link and channel assignment are initially made by using global channel/link assignment algorithms. We use some shields or by physical separation among antennas avoid the interference among multiple radios in one node. The gateway is used to connect the internet and also connected to the other mesh routers. The network also supports the QoS. Each mesh node in WMN periodically sends its outgoing link information to the control gateway through management message. Based on this information, the gateway controls the admission of requests for voice or video flows.

2) *ARS features*

1) Localized reconfiguration: To recover from link failures ARS generates reconfiguration plans which make changes only the faulty area and do not disturb all the network settings.
2) QoS-based planning: ARS generates only QoS satisfiable plans.
3) Link-quality monitoring based autonomous reconfiguration: When ARS detects a link failure based on given measurements and link's QoS constraints, it quickly and autonomously initiate network reconfiguration.
4) Cross-layer interaction: ARS interacts across the network and link layers for planning.

C) *ARS Operations*

Wireless mesh network face the problem of link failures. So to recover from that failures autonomous network reconfiguration system (ARS) is used. ARS is equipped with a multi-radio WMN and a reconfiguration planning algorithm. Multi-radio WMN helps to autonomously reconfigure networks channel, radio and route assignment settings as local as possible. ARS reconfiguration planning searches only feasible local configuration changes available around the faulty area. ARS help to avoid propagation of QoS failures to neighboring links. Advantages of ARS are:

1. Help to increase channel efficiency
2. Route repair
3. Reduce the delay

Wireless mesh networks with mesh node and wireless link have some source node and destination node. Source node sends packets to destination node periodically. There is a one control gateway. That maintains all the node details and connection details. Each node in the network monitors its outgoing wireless link condition at each time (eg: 10 sec) and report the information to gateway through management message. When there is a link failure occur during packet transmission from source node to destination node, ARS in the source node is executed. Source node finds its neighboring nodes and finds a minimum distance node from the source node and declares it as a leader node. Leader node help to reduce the network traffic during packet transmission. Leader node sends a new route request message to gateway node. Gateway node contain updated table of all nodes and connection. Depending on the table gateway send a new route to the leader node. Leader node sent it to the source node. After that source node send its packets to the destination node through new route.

D) Comparison of ARS and AODV

Here we compare two routing protocol: ARS and AODV. Comparison is based on the performance calculation of ARS and AODV. Performance is calculated using different QoS factors like energy, throughput, and packet deliver ratio and delay.

1) Ad-hoc on demand routing protocol (AODV)

An ad-hoc network uses different routing protocol for proper routing. The traditional routing protocol cannot be used to ad-hoc networks because the mobile nodes in ad-hoc networks have high mobility. So we use different routing protocol. Routing protocol can be classified into different types which includes on-demand routing protocol, table - driven routing protocol etc. Here we use on-demand routing protocol AODV.

AODV is used to find the path to be followed by data packets from source node to destination node. It is a reactive protocol means that a route is established only when it is required by a source node for transmitting data packets .It is capable of unicast and multicast routing .The routing table of each node contains only information about the next hop to the destination and a sequence number received from the destination. It uses three types of message: Route request, Route reply and Route error messages. So the network traffic is high in the network when we use AODV routing protocol.

When a wireless mesh networks send packets from source node to destination node through AODV routing protocol face a link failure it recover that failure and find a new route after a long time. So it produces high delay in the network. The performance of ARS and AODV is calculated using different factors.

1) Energy: Energy must be optimum for a routing protocol. We can calculate the total energy of all the nodes in the network. We can assign some initial energy and can find final energy of each node. From that we can calculate consume energy by subtracting final energy from initial energy of each node.
2) Throughput: Throughput is the amount of data delivered per unit time.
3) Delay: Each packet is sent from a source node at some time called start time. Packet must be reach at the destination at another time called end time. Delay can be calculated by finding the difference between start time and end time of packet transmission.
4) Packet delivery ratio: The number of received packets divides with number of number of sent packets by source node give the packet delivery ratio.

IV. PERFORMANCE EVALUATION

We have evaluated ARS and AODV via simulation. We describe our simulation methodology and then present the evaluation results on ARS and AODV.

A) Simulation model

We used an operating system Ubuntu 10.04 and Network Simulator version 2.34 and also made use of tcl scripts, awk files, trace files, xgraphs etc. The Network Simulator is an event based simulator through which we can see simulation scenario through an animator called Network Animator (NAM) and by executing the tcl script we could obtain the corresponding trace files. This trace files records each and every event occurred during the simulation. Using awk file

We proses the data from trace file and based on that awk scripts we can plot the xgraphs for different parameters. Table 4.1.shows the simulation model we have used.

Table 4.1 Simulation model

SIMULATOR	Network Simulator 2
NUMBER OF NODES	51
TOPOLOGY	Mesh Topology
INTERFACE TYPE	Phy/Wireless Phy
MAC TYPE	802.11
QUEUE TYPE	DropTail/ PriQueue
QUEUE LENGTH	200
ANTENNA TYPE	Omni Antenna
PROPAGATION TYPE	Two Ray Ground
TRANSPORT AGENT	TCP
APPLICATION AGENT	CBR
SIMULATION TIME	5 s

B) Results

The Figure.4.1 shows network scenario of WMNs with mesh nodes and wireless links. Packet transmission is done using AODV protocol.

The Figure.4.2 shows WMN network with ARS routing protocol.

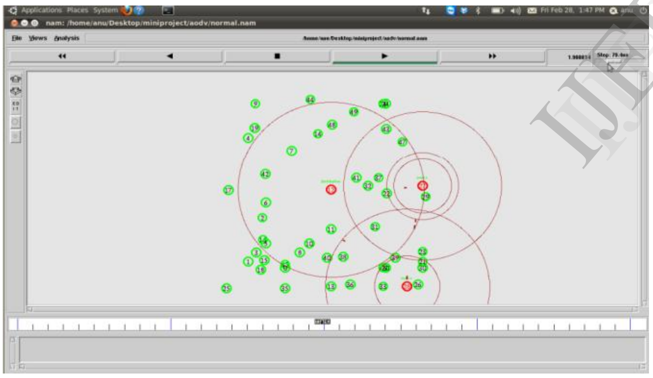

Figure 4.1.Packet Transmission using AODV protocol

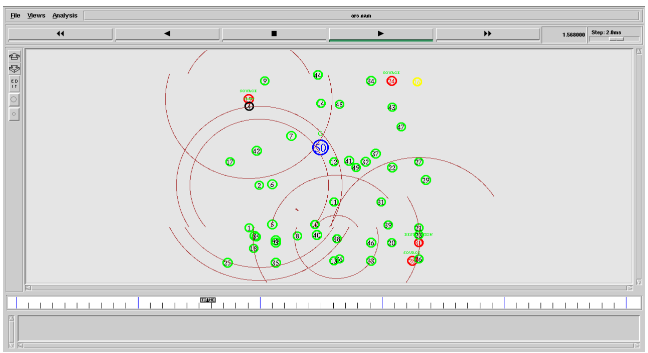

Figure.4.2.Packet Transmission using ARS protocol

We compare the ARS and AODV using xgraph. Xgraph is plotted by using different parameters and their values. Figure.4.3shows throughput comparison of ARS and AODV.ARS have high throughput than that of AODV.

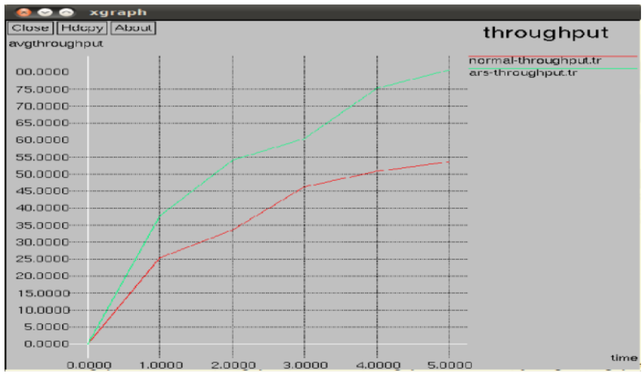

Figure 4.3.Troughput comparison of ARS and AODV

Figure.4.4 shows delay of ARS and AODV. Delay is high for AODV.

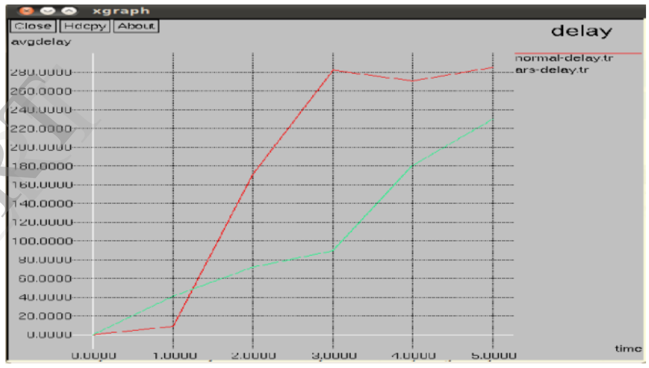

Figure 4.4. Delay comparison of ARS and AODV

Figure.4.5 shows packet delivery ratio comparison. It's high in the case of ARS.

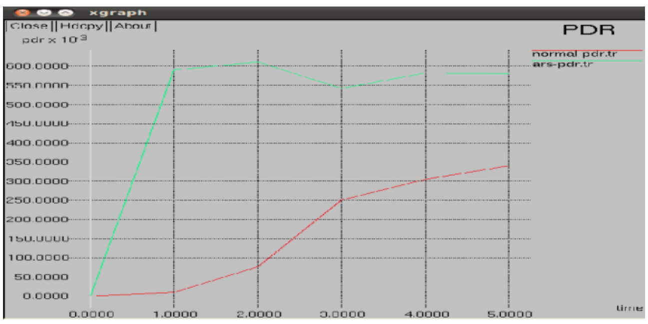

Figure 4.5 Comparison of packet delivery ratio of ARS and AODV

V FUTURE SCOPE

ARS shows some considerable amount of packet loss and also it has high energy consumption. The leader election or ARS is not effective. So we can use improved autonomous network reconfiguration system (IARS) to overcome the limitations of ARS. It is a modified version of ARS. It decouples network reconfiguration from flow assignment and routing by assign a threshold value for each node. Before sending the packets each source node checks the threshold value of its neighbouring node. So it can find a path of minimum delay and path cost. Leader election is based on the threshold value and good distance of the node

VI CONCLUSION

In this paper, the link failure recovery of wireless mesh networks is considered as the main objective. For that we use autonomous network reconfiguration system (ARS) which enable a multi-radio WMN to autonomously recover from the local frequent link failures. It requires only local network setting changes with a reconfiguration planning algorithm. It shows high throughput and good performance when compared to AODV protocol.

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