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Self Organizing Wireless Mesh Network

P. Sharnya and Jennifer S. Raj

Department of Electronics and Communication Engineering,
Karunya University,
Coimbatore, Tamil Nadu, India

ABSTRACT: A communication network with radio nodes which is organized in a mesh topology is called as wireless mesh network or WMN. They are used for variety application such as building automation, transportation, citywide wireless Internet services etc. The WMN experience link failure due to application bandwidth demands, channel interference etc. These failures will cause performance degradation. Reconfiguration is needed to preserve the network from dynamic link failure. The most of the existing algorithms are not able to give full improvement at the time of dynamic link failure. The resource allocation require global configuration changes, greedy channel assignment algorithm might not be able to realize full improvement. The proposed work is for reconfigure the network at the time of dynamic link failure. Autonomous reconfiguration system (ARS) is used to reconfigure the network. The system generates necessary changes in channel assignment in order to recover from link failure. The performance is evaluated using different types of quality parameters such as throughput, PDR, delay. Comparing with existing schemes this will provide fast recovery.

KEYWORDS: IEEE 802.11, Self organizing, Wireless, Mesh network, Wireless link failure.

1 INTRODUCTION

Wireless mesh network or WMN is a network having mesh clients and routers connected in mesh topology. It consists of mesh routers, mesh clients and gateways. Laptops and wireless devices are mesh clients. Each node serves as a host as well a router, because it forwards the packet to the other node if they are in not in the range. Here the mesh routers forward the traffic to and from the gateway. The integration with other network such as internet etc is done through gateway. There is no need of physical connection between every access point and internet. A wireless mesh network is reliable and it offers redundancy. When a node or route fails other node can communicate with each other. WMN have greater range due to packet relying. Shorter hops will provide higher throughput. These are the advantages of WMN over conventional networks.

The application of wireless mesh network include public safety, citywide intranet services, intelligent transportation system, building automation, broad band home networking etc. Application of WMN provides more flexibility compared to peer to peer network.

WMN experience link failure due to interference, mobility, application bandwidth demand etc. This will lead to degradation of network performance. It can be avoided by using reconfiguring the network. Here an autonomous reconfiguration system is used to reconfigure the network. Each node in the mesh network will monitor its outgoing and incoming link periodically. Then this link quality information will send to the gateway. If any link failure detects the reconfiguration process will occur.

1.1 REVIEW OF LITERATURE

Wireless mesh network or WMN is a network having mesh clients and routers connected in mesh topology. Mesh routers, mesh clients and gateways are the components of WMN. A WMN is reliable and it offers redundancy. WMNs are widely used for different applications such as broadband home networking, building automation, transportation system, public safety and environment monitoring [1]. Different forms such as multiradio /multichannel systems are used to meet the increasing capacity demands [2]-[3]. The network capacity will be decrease when the number of channel is larger than number of interfaces per nodes [2]. Work load aware routing algorithm is used for opportunistic routing. It will find out high workload nodes and assign channels [12]. Topology and interference aware channel assignment architecture (TIC) is a multi radio IEEE802.11 mesh network architecture which select channels which having high throughput paths [13].

Many solutions are used to recover from link failure in a WMN. They are having many limitations. The autonomous network reconfiguration system requires computational overhead and reasonable bandwidth [1]. The bandwidth issue is mainly due to interference due to neighboring path [14]. The resource-allocation algorithm [8]-[9] is used for initial network planning. Global configuration changes are required for this resource allocation algorithm. These global changes are not desired for frequent link failures. The faulty link settings alone are changed in greedy channel-assignment algorithm [10]. The greedy algorithm is used for partially overlapping channel assignment which will improve the network throughput [15]. These greedy changes will not be able to achieve full improvement. Network level path diversities are used in fault-tolerant routing protocols for avoiding the faulty links. The fault-tolerant routing protocols such as local routing [24] or multipath routing [25] require more network resources.

2 Need of this Study

WMN is deployed widely for different applications. Capacity demand will increase according to the application. The WMN will experience link failure. These failures occur due to channel interference, mobility or dynamic obstacle. This failure will degrade the network performance. The existing technology will have many drawbacks. Localized reconfiguration require network planning algorithm. Channel assignment algorithm [8]-[9] gives only the initial network planning. The degree of configuration changes is not considered here. Hence this algorithm requires global configuration changes. Greedy channel assignment algorithm [10] will consider only local area for channel assignment. This will reduce the network changes, but it will suffer from the ripple effects. Any local change will cause the change of additional network setting at neighboring nodes. This can be avoided by changing in to tree topology. This will leads to reduction in path diversity and network connectivity. Interference-aware channel assignment algorithm minimizes interference and it will use additional channels to improve overall network capacity.

3 Method

There are 4 steps in the case of reconfiguration. They are network monitoring, group formation, feasible plan generation and reconfiguration.

3.1 Network Monitoring

Each node in the mesh network monitors its incoming and outgoing link periodically. At each time interval t_m nodes will send the link quality measurement to the gateway. Here the node will measure the link quality (l_q) and it is compared with the threshold value which is set earlier. If the link quality is above the threshold ($l_q>l_{th}$) then the link is good. If the link quality is below the threshold ($l_q<l_{th}$) then the link is failed. Once the link failure detected then the group formation process starts.

3.2 Group Formation

The group formation starts after the link failure detection process. Here the nodes which are using the faulty links will forms a group. The group formation period is t_f. The group formation is done in channel c of link l, which is a faulty link. After the group formation next step is leader node selection. Each member in the leader node will compare its energy with all other nodes in the group. After this higher energy node is chosen as leader node. This leader node will send the planning request message to the gateway. Once the planning request is send the next process starts.

3.3 Feasible Plan Generation

When the gateway receives a planning request it will compare this request with other requests. After that it will generate reconfiguration plan according to the planning request. If the network contains so many other failures, then there will be so many requests to the gateway. At this time the gateway synchronizes the entire request. After the synchronization gateway generate reconfiguration plan. After the reconfiguration plan generation the reconfiguration process will occur.

3.4 RECONFIGURATION

After the reconfiguration plan generation the reconfiguration process will starts. The gateway will send the reconfiguration plan to the leader node. This leader node will send this plan to all other nodes in the group. The group members change their link settings according to the reconfiguration plan. This plan will moves to the neighboring nodes.

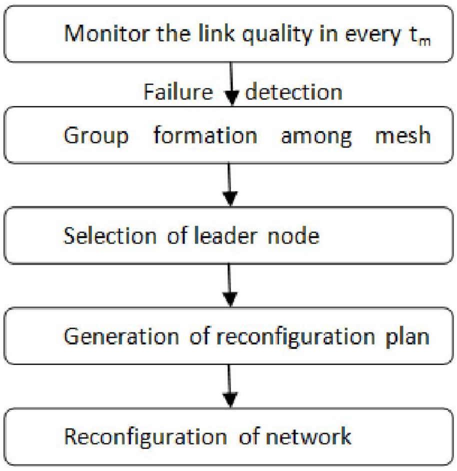

Fig. 1. Flow Chart

3.5 ALGORITHM

(1) Monitoring period (t_m)

1: **for every** link j **do**

2: measure link-quality (l_q)

3: send monitoring results to a gateway

(2) Failure detection and group formation period (t_f)

4: **if** link (l_q) violates link requirements (l_{th}), that is ($l_q<l_{th}$) **then**

5: request a group formation on channel C of link l

6: participate in a leader election if a request is received;

(3) Planning period (t_p)

7: **if** node is elected as a leader **then**

8: send a planning request message to a gateway;

9: **else if** node is a gateway **then**

10: synchronize requests from reconfiguration groups

11: generate a reconfiguration plan

12: send a reconfiguration plan to a leader of faulty group

(4) Reconfiguration period (t_r)

13: **if** includes changes of node **then**

14: apply the changes to links

15: relay to neighboring members, if any

3.6 Network Model

The topology is shown in Fig 1. Here 25 nodes are arranged in grid topology. The red node is gateway and all other are mesh routers. If any link fails the node which uses the faulty link will forms a group and a node is selected as leader node. This leader node will send the planning request to gateway. This gateway will generate the reconfiguration plan according to the planning request. The gateway will send the reconfiguration plan to the mesh routers. The mesh routers will execute the reconfiguration plan.

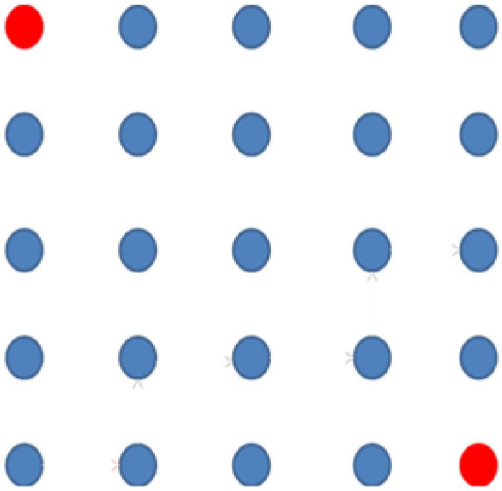

Fig. 2. Network Model

4 Results and Discussions

The performance is evaluated using ns2 simulator. IEEE 802.11 is used here. 25 nodes with grid topology are created. The evaluation parameter is shown in table 1.

Table 1. Evaluation Parameters

Parameter	Value
Area	200 x 200 (m^2)
Channel	Channel/WirelessChannel
Propagation model	Propogation/TwoRayGround
Network Interface	Phy/WirelessPhy
Interface Que Type	Queue/DropTail/PriQueue
Interface Queue length	50 packets
Total number of mesh nodes	25
Routing protocol	AODV
Transport layer protocol	TCP
MAC Interface	Mac/802.11a
Antenna Type	Antenna/OmniAntenna
Application	FTP

The performance of the network is evaluated in terms of Throughput, Packet Delivery Ratio (PDR), and Delay parameters, defined as follows,

- Throughput is the average rate of successfully transmitted data packets over the communication channel's capacities
- Packet Delivery Ratio (PDR) is defined as the ratio of the total number of successfully transmitted data packets to the total number of data packets sent from the source to the destination.
- End-to-end delay refers to the time taken for a packet to be transmitted across a network from source to destination.

The mesh network is created with 25 nodes with grid topology. The performance is analysed for different conditions are analysed. The throughput comparison is done for a network with and without reconfiguration. The performance is analysed for mobile nodes and stable nodes.

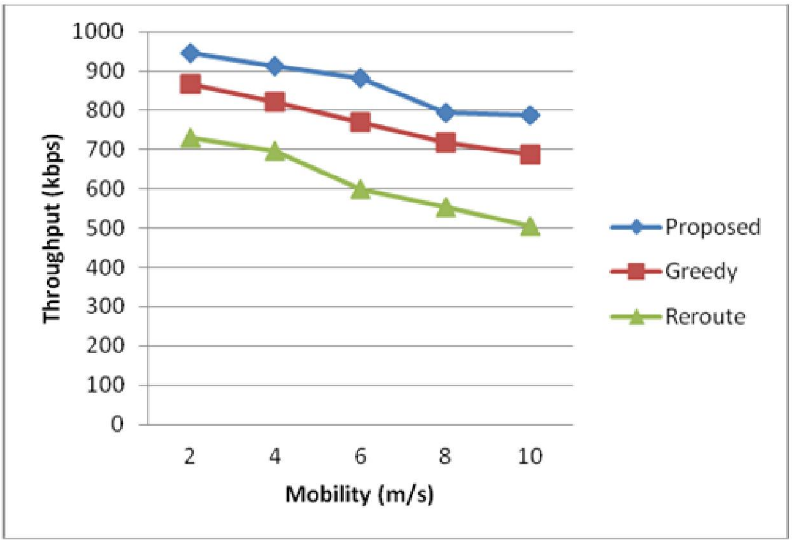

Fig. 3. Throughput Vs Mobility

Throughput Vs mobility graph is shown in Fig 3. The throughput is decreases with increase in mobility. Here the proposed work have higher throughput than the greedy algorithm. The network with ARS provides 15% improvement than the existing greedy algorithm.

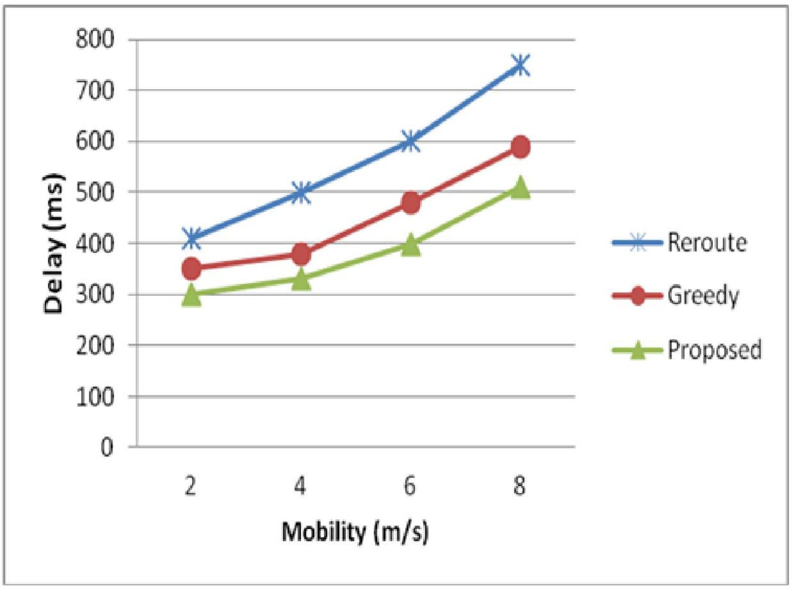

Fig. 4. Delay Vs Mobility

The delay Vs mobility graph is shown in Fig 4. The delay will be increasing as the mobility increase. Here the delay for different algorithms is compared. The delay for the proposed model is less than the existing technique.

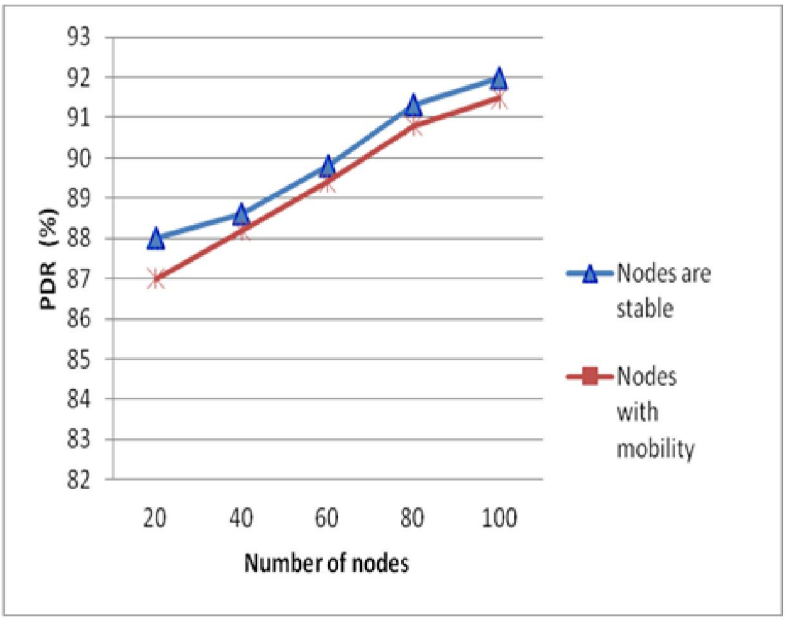

Fig. 5. PDR Vs Number of nodes

The PDR Vs number of nodes is shown in Fig 5.4.4. When the number of nodes increases the PDR will increase. The packet delivery ratio will be less for network with mobile nodes than the network with stable nodes.

5 CONCLUSION

A wireless mesh network is a communication network having mesh routers and mesh clients connected in a mesh topology. Dynamic link failure due to interferences will lead to network performance degradation. The link failure is avoided using autonomous reconfiguration system. This will provide a fast recovery from link failure using reconfiguring the network. This ARS technique will improve the network performance compared with existing technology. This will give a fast recovery from the dynamic link failure.

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