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Wireless Mesh Network Link Failure Issues and Challenges: A Survey

Rucha Pawar[1]*, Vailshali Munguwadi[2], Pranav Lapsiwala [3]

[1]Electronics and Communication Dept., Sarvajanik College of Engineering, GTU, Surat, India
[2]Instrumentation and Control Dept., Sarvajanik College of Engineering, GTU, Surat, India
[1]Electronics and Communication Dept., Sarvajanik College of Engineering, GTU, Surat, India

Corresponding Author: ruchapwr@gmail.com Tel.: 9033733501

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Abstract: Wireless Mesh network gives the new definition in wireless broadband technology with the advantage of various enhanced features such as self organising, self-configuring and self-healing which helps to significantly reduce the complexity, cost and enhances network capacity, connectivity and flexibility. WMN integration with multiple mesh client and ad-hoc network demands reliability.This article depicts the issue of frequent link failure in WMNs and their effects on throughput, congestion and energy consumption. As compared to conventional ad-hoc network, wireless mesh network covers large geographical region. Wireless network uses fidelity standard for media access and communication that is highly immune to noise and interference. Therefore, link and route maintenance is always a challenge for the researchers. This paper presents study of WMN different characteristics, link failure issues, advantages and its drawback. Such a mesh network can be used in the development of IoT, Smart Cities applications, electronic noise system and etc..

Keywords: Wireless mesh network; Link failure; Link quality; WMN Architecture**.**

I. INTRODUCTION

Wireless Mesh Network (WMN) is one of the key technologies which flawlessly connect wide area with simplicity and low cost which is the requirement of next generation in wireless communication. The capability of WMN such as self organising, self-configuring and self-healing significantly reduces the complexity, cost and enhances network capacity, connectivity and flexibility.

WMNs are considered as one of the type of Ad-hoc network. As WMNs have more massive algorithm and design principles it makes them different from conventional Ad-hoc networks. Some of the differences between WMNs and Ad-hoc network are as follows [13], (a) Relay nodes of Ad-hoc network have is higher mobility than WMNs, (b) Mesh routers in WMN forms the backbone of network, which provides large coverage, connectivity and robustness. But in ad hoc networks, the connectivity depends on the individual contribution of end-users. (c) The gateway and bridging functions provided by mesh routers allows the fusion of WMN's with other networks such as Internet, cellular, IEEE 802.11, IEEE 802.15, IEEE 802.16 and sensor networks. Unlike ad hoc networks, the routing and configuration functionalities of the mesh routers reduces the load on end-user devices. (d) The mesh routers can have multiple radios to perform routing which improves the capacity of the network. On the other hand, ad hoc networks use same channel for routing, network access, etc., which significantly results in poor performance.

Wireless mesh networks can simply, effectively and wirelessly connect the entire city using low-cost and existing technology. Traditional network depends on a small number of wired access points or wireless hotspots to connect end users. Whereas, wireless mesh network is network which have hundreds of wireless mesh nodes that communicate with each other to distribute the network connection across a large area. Thus, WMN provides wireless technology a lot of applications, e.g., enterprise networking, building automation, transportation systems, smart cities, etc.

Despite of huge advantages, WMNs have several issues and challenges. Several characteristics such as mobility, Variable transmission power, Hidden nodes, transmission delays, Throughput capacity and Transceiver power can make a significant difference in performance of network. High interference, unique traffic pattern and efficient routing requirement from mesh network allow research for critical factors to increase performance of network.

This chapter includes the basic idea of Wireless Mesh Network (WMN); the different challenges faced by WMN and application of WMN. It also includes the motivation behind the need of route maintenance in WMN and basic idea for the same which follows scope of work.

A. Network Architecture

Wireless Mesh Network consists of three types of nodes: Mesh Router, Mesh Client and Gateway Router. Figure 1 shows the Architecture of WMNs.

1) ***Mesh Router:*** Mesh router acts as a backbone of the mesh network. Its function is to maintain connectivity between nodes and perform routing. In addition to improve flexibility of network mesh router carries a multiple wireless interface depending on applications requirement. In contrast with the conventional router, wireless mesh router can achieve a same coverage with much less transmission power. Routers in Wireless mesh network are wirelessly interconnected and act as relay to provide service to the end users.
2) ***Mesh clients:*** Mesh clients are generally user devices such as laptops, PDA, pocket PCs, IP phone, RFID reader, etc. They can also acts as a host or as a router in network and usually have only one radio interface. Mesh client provides peer to peer communication between nodes. Wireless mesh client architecture is shown in figure 2. Whenever node or user wants to communicate to other user or node it has to pass through multiple hops to achieve destination node. Various routing techniques are use to accomplish successful and efficient communication between nodes.
3) ***Gateway router:*** In mesh network gateway router connects router and clients directly to the internet or through wired network which connects to the internet. Thus Gateway router acts as a link between wireless mesh network and internet.

Some of the characteristics can make a significant difference for the performance of wireless mesh networks they are as follows,

- **Self-Configuring and Self-healing:** wireless mesh networks allows the convenient addition and removal of nodes without degrading the performance of network. Hence called as self-configuring network. Thus, Self configuration allows easy and rapid deployment of nodes. The ability of WMN to easily adjust in rapid changing environment provides us a self healing nature of WMN. Whenever there is high traffic load in a particular route or a link breakage WMN allows traffic through available route. Adding more routers can also increase the reliability of network, but as routes increases, interference ratio also gets increased.

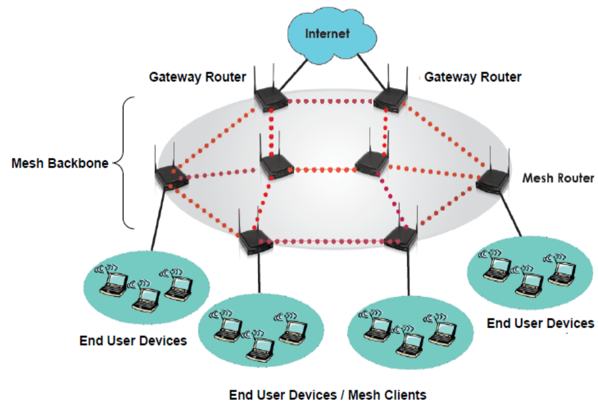

Figure 1.Wireless Mesh Network.[1]

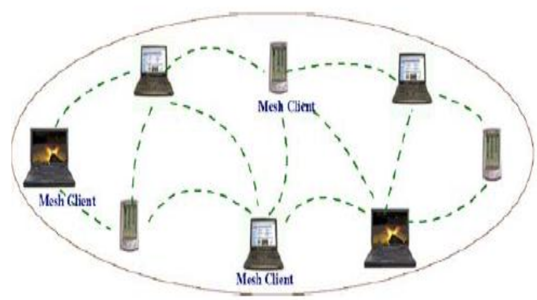

Figure 2. Mesh clients.[1]

B. WMN Characteristics And Challenges:

- **Easy Deployment and Scalability:** Many of the application there is need of large and stable network. As wireless mesh network do not have a fix or particular architecture nodes can be easily and rapidly deployed. Thus, network can be enlarge and narrowed easily.
- **Dynamic structure:** Nodes are free to move in WMNs this allows the change in network structure.. WMN maintains user connections and handoff them quickly from one access point to another as the users roam out of the coverage area of mesh network. Thus, WMNs provides very dynamic network structure.
- **Energy Constraint and Channel capacity:** Mesh network is not much concern to the energy constraint because it have powerful routers as a backbone of network. Use of a multi-hop wireless network greatly increases channel capacity and achieves higher throughput.
- **Compatibility with existing wireless networks**: WMNs have multiple type of network access like support for internet and peer to peer communication this features

provide the compatibility with existing wireless network such as WiMAX, Zig-Bee and cellular networks.

Link-failures are often a major cause for performance degradation of mesh networks. By detecting and avoiding various parameters and undesirable topologies we can reduce a high frequency of such failures. WMNs, irrespective of its simplicity and high fault tolerance, face significant limitations. Some of the critical factors that degrade a network performance are as follows:

- **Throughput capacity:** In wireless mesh network several factors affect the throughput capacity of network. Some of factors such as characteristics of MAC protocol, the exposed node problem, the hidden terminal problem and high error rate in the wireless channel etc... Path length is one of the factors that affects throughput, as path length increases throughput decreases. Whenever nodes share data between them especially when CSMA/CA-based MAC protocols are in use throughput gets affected. For example, when node 1 transmits to node 2, nodes 2 and 3 cannot start another transmission. Node 2 is prevented from a simultaneous transmission as the wireless interface, in most WMNs is half-duplex. This expose node problem causes throughput degradation.[4]

- **Fault Diagnosis:** Route failures in WMN are generally due to various causes such as routing overheads, interference, channel load, congestion, channel errors etc... Interferences such as, radio interference which changes original signal and causes a bit alteration due to this link layer may drop packet and resulting in transmission failure, Channel connection interference which forces the station to wait until the channel is free to begin its transmission also called as a MAC layer interference, Intra-flow Interference is an interference within a flow traversing multiple wireless hops. Successive links in the path of a flow can interfere with each other and impact performance of network, Inter-flow Interference refers to as interference between flows sharing the same channel. This causes instability in network.

- **Efficient Bandwidth management:** In wireless mesh network when source node transmits data to the group of destination node is called as multicasting communication. This data is send only once and it is forwarded and replicated to other user by intermediate nodes towards destination node. Thus, bandwidth is share by each of the node present in network. During this bandwidth assignment, some node may not get enough bandwidth as per their requirement. The shared wireless medium limits the capacity of a multihop wireless network, theoretically 1/4 to 1/3 of the raw link bandwidth is provided to the application layer [2].While, in 802.11-based multihop networks achieve only 1/7 of the raw bandwidth using popular transport protocols. In addition to this network also exhibits extreme unfairness, including starvation, for flows which originate away from the gateway. This starvation is also observed with Transmission Control Protocol (TCP) which allows blockage of links in wired networks [3]. Hence efficient bandwidth allocation is necessary by proper channel allocation, monitoring the channel, reducing unwanted traffic, etc...

- **Hidden nodes:** In wireless network a beacon is a short packet that is transmitted periodically to a one-hop neighbour’s node and its function is to detect neighbours and to keep links alive. The probability of losing a beacon due to a packet collision while transmissions from hidden nodes is much larger than the probability of losing beacons due to transmissions from one-hop neighbours.

- **Transmission delays:** WMN node may have to handle multiple streams of traffic arriving from neighbouring nodes, and the amount of processing it has to perform could lead to excessive queuing delay. This limits the performance of any large scale WMN. One way to overcome such limitation is to introduce additional short-cuts or a void long-links into the network this allow network traffic to bypass many intermediate relaying nodes on the way to the destination nodes. Many algorithms are used, Genetic algorithm, to avoid this problem.

- **Radio techniques**: Radio techniques are one of the critical factors to design Wireless Mesh network. Wireless radio has undergone through rapid change due to changing technology of semiconductor, RF and communication theory. The need to increase capacity and flexibility of wireless systems has given rise to many new approaches, such as directional and smart antennas, MIMO systems and multi-radio/multi-channel systems. Wireless radios can be improved by using more advanced radio technologies such as reconfigurable radios, frequency agile/cognitive radios, and even software radios have been used in wireless communication. Directional antennas can be use to reduce exposed nodes, but they also generate more hidden nodes. These radio technologies are not fully developed but have a capability of dynamically controlling the radio [1].

C. Motivation:

As the wireless network is unreliable network it suffers from transmission failure problem. The main motivation is that transmission failures in Wireless mesh network are generally due to:

- **Radio communication link Interference,**
- **Channel load and**
- **a burst of channel errors,**

resulting in a link failure notification by link-layer to the network layer. On demand routing protocols consider the link failure notification systematically as an actually ‘‘broken’’ link (link breakage) and therefore consider the route to be broken (route breakage).Frequent route breakages can seriously degrade performance. Therefore, there is need of a mechanism which can identify a solution for false and frequent route breakages.

II. DIFFERENT MECHANISMS USED FOR LINK FAILURE MANAGEMENT

A. Mesh Routing Protocol:

In WMN routing is important to achieve good quality performance of network. Various internet routing protocol have been developed and they performed well for many years to come. There are some demands that must be satisfied by routing protocol for sustainable network performance they are: the failure nodes and broken links must be quickly rerouted and detected, routing protocol must have lower number of overheads so that network can be scale easily, to insure QoS they must select a best route for different traffic classes.

Jangeun Jun, Mihail L. Sichitiu presents Mesh Routing Protocol as a internet protocol which is simple and easy to implement. MRP provides minimum delay, Route stability, maximum bandwidth, and minimum packet loss. In WMN gateway is use as a communication link between routers and internet, MRP maintains a routing tree between client and gateway this lead to mirror the data in network which helps to eliminate route overheads. These protocols are only suitable for centralize networks.

In MRP whenever a new node joins a network it will demand a neighbouring gateway or nearest neighbour node for a route. In route discovery phase RDIS message is send by the node but it is not flooded in entire network, this message is only received by one hop neighbouring nodes. So initially joining node is in disconnected state. Thus reply packets are send from neighbouring nodes called route advertisement packet (RADV).This packets are unicasted by some delay to avoid collision. Once joining node receives all the RADV it will select routes as per node requirement. Thus a route is establish to transfer data to and from internet but this is only called as half connected state in paper [14].

For a node to be in fully connected state it must be register with gateway .this process is divided into two steps first node send a registration request (RREG) toward gateway and intermediate node creates a new entry of this route an establish an reverse rote path. after receiving request packet gateway sends acknowledgment packet RACK towards node thus process gets completed.

MRP also considers route failures it unicast spatial route check packet. If reply is recived then node is considered as fully connected if not then it is considered as disconnected.

1) Verification of Link Status in MRP:

Link failure is represented by failure to forward data packets to next hop nodes. If there is a temporary failure of link and it will leads to enter a node in disconnected state. This failures always degrades protocol performance. Two states are considered in MRP to avoid unnecessary disconnections:

False disconnection: if node enters in disconnected state due to temporary disable link. True disconnection: if node enters in disconnected state due to permanent disable link. Three important parameters are considered to avoid false disconnection:

- **Timeout value**: provides information of how long node should stay in verify link state before it transition to disconnection state.
- **Traffic load intensity**: link status must be check at various average packet intervals.
- **Mobile intensity**: In network nodes are randomly deployed and they are continuously moving hence the end to end delay of the packet received by the node is needed to be check.

$$Routing\ Overhead = \frac{\sum_{n=1}^{N}\sum_{p=1}^{p_n^{cs}} b_{n,p}}{T_{sim}\times N}\ \left(\frac{bps}{node}\right) \qquad \text{Eq.1.}$$

$$PDR \equiv \frac{\sum_{n=1}^{N} P_n^{dr}}{\sum_{n=1}^{N} P_n^{ds}}\ (\%) \qquad \text{Eq.2.}$$

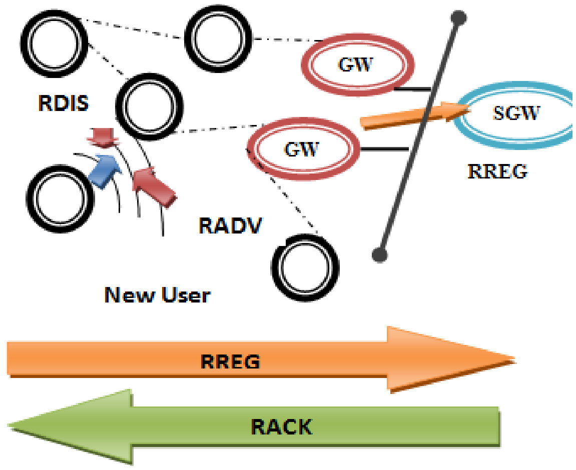

Figure 6. MRP route establishment message sequence.[14]

$$Delay \equiv \frac{\sum_{n=1}^{N}\sum_{p=1}^{p_n^{dr}} D_{n,p}}{\sum_{n=1}^{N} P_n^{dr}} \quad (ms/packets) \qquad \text{Eq.3.}$$

Where,

N is total number of nodes.

p_n^{cs} , is the total number of unicast routing control packets sent by the nth node,

$b_{n,p}$, is the number of bits in the pth packet received by the nth node,

T_{sim} , is the total simulation time,

p_n^{dr} , is the total number of unicast data packets received by the nth node,

p_n^{ds} , is the total number of unicast data packets sent by the nth node, and

$D_{n,p}$, is the end-to-end delay experienced by the pth packet received by the nth node.

Selection of time out value is an important factor if large value is selected false disconnection will be reduce but causes delay in true disconnections and if small value is selected true disconnection will be promptly recognize but increases number of false disconnection.

According to author of [14], if time intensity is varied from1.5 to 4.0s and mobile node intensity is control from 0 to 49 then we can have timeout value of least 3s to correctly detect false and true disconnection.

B. Autonomous link recovery system:

ALR is a distributed control system that allows a mutiradio WMN to autonomously recover link failure in network [15]. It can be easily used in IEEE 802.11 WMN having multiple channels and radio.ALR effectively satisfy QoS constrains of various applications by using network reconfiguration planning to recover link failures and allows twice more flow than static assignment. Despite of this advantages ALR have reasonable bandwidth and computational overheads.

In wireless mesh network frequently experience a link failure and needs to reconfigure settings to avoid performance degradation. While in ALR system a feasible local configuration is first found around a failure area and automatically reassign to the network setting among mesh routers.

ALR process is divided into four stages: first monitoring stage, second failure detection, third planning stage and reconfiguration stage. Initially ALR continuously monitors quality of link at each node, if any link does not satisfy the link requirement then request is made to form a group on channel of the failure link. Request of planning is send to the gateway by the node and if failure node is gateway then generate a reconfiguration plan for that gateway and send it to the leader of that gateway. Apply the require changes to get link recovery. ALR applies a reconfiguration plan based on QoS constrains. It first identifies the QoS stability of reconfiguration plan and expected benefits of channel.

1) Reconfiguration planning for link failure:

Reconfiguration plan allows network to change link configuration to get recover from link failures. Each fail link has many reconfiguration plan ALR selects a single plan which satisfies a strict QoS constrains. Reconfiguration plan s divided into three processes: Feasibility, QoS satisfiability and Optimality.

All the failure nodes information and connectivity requirements are provided to obtain feasible plan. This plan provides information about changes in link configurations and there combinations in faulty areas. During this process ALR need to take care of maintaining the connectivity with each radio, because each radio have multiple neighbouring node and due to change in configuration of faulty link may affect the configuration settings of neighbouring link. Example, as shown in figure 8 for failure link CI, ALR combines the generated primal neighbouring link to get feasible plan. For example, plans *S(C,I)3→6* and *S(H,I)3→3* in Figure 3 cannot be connected because each change requires a same radio of node I to setup a different channel. Thus after two stages 11 feasible solutions can be obtained and if ALR does not find the local solution it increase the number of hops (k) to find the solution

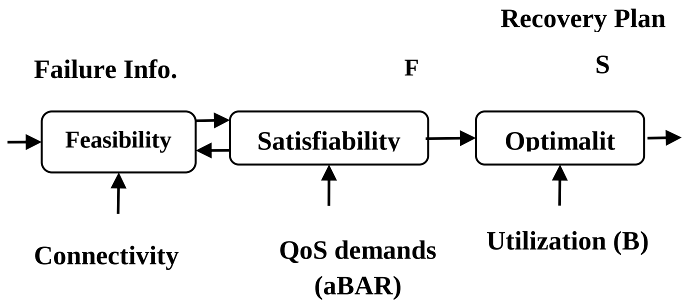

Figure 4.Reconfiguration planning for Link Failure [15]

These sets of feasible plans are provided to next stage to obtain QoS satisfying plan. From different feasible solution only those solution are selected which satisfies QoS demands.This can be done by checking expected busy air time ratio, it is given as

$$aBAR = \sum_{l \in L(k)} (q_l / C_l)$$

Eq.4.

Where, C is link capacity which is based on link quality information packet delivery ratio and data transmission rate. If the information is obsolete then ALR detects a link failure and another plan is found which satisfies QoS demands by using lazy monitoring. q is link bandwidth requirement , k is a radio ID, a link associated with radio *k*, and *L(k)* the set of directed links within and across radio *k*'s transmission range. aBAR must be less than 1.0 to satisfy the QoS requirement.

Now to get a reconfiguration plan ALR uses a benefit function which is given as,

$$B(p) = (1/n) \sum_{k=1}^{n} \beta(k)$$

Eq.5.

Where, *β(k)* is the relative improvement in the airtime usage of radio *k*, and *n* the number of radios whose *β(k)* has changed from the plan. B(p) helps to decide reconfiguration plan that improves overall channel utilization.

When there is a multiple reconfiguration plans ALR has to break a tie among them. To break a tie ALR uses the number of link changes. Changes in link configuration causes a small amount of flow interference, the less changes in link configuration, the less network interference.

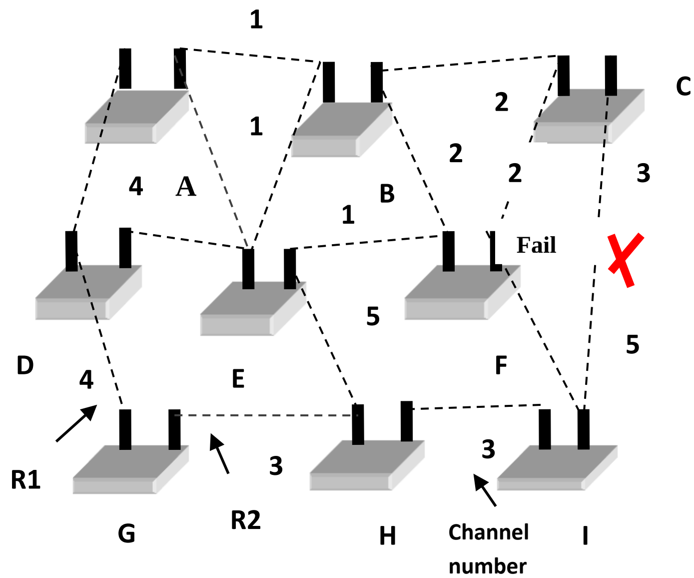

Figure 5. Multiradio WMN.AWMNhas an initial assignment of frequency channels as shown. The network often experiences wireless link failure and needs to reconfigure its settings [15]

C. Route Stability Mechanism:

Route instability in wireless backbone network is a common problem. This instability in network is due to frequent route breakages. Existing protocol considers the temporary link failure as a permanent route breakage. This significantly decreases performance of network. Route stability is important factor for a wireless mesh backbone network which must act as a high speed network for a user.

Usman Ashraf, Slim Abdellatif and Guy Juanole in [6] present a route stability mechanism which focuses on detection of route breakage and performance improvement of Wireless Mesh Access Networks. In this paper the local node base mechanism is used for justifying the effect of congestion on link stability. They differentiate the poor quality link and heavily congested link so to improve the link breakage detection mechanism.

In WMN route discovery and route maintenance are two main phases to find routes to unknown destinations. Various routing protocols are used such as DSR, AODV to establish routes with minimum interference and low routing overheads. In route discovery phase route request and route reply packets are used to establish new route between nodes .once the route is established route maintenance phase starts in which the broken links are detected and new route is found using route discovery. Every node in network detect the link as broken when after several retries to send a packet to next node fails (in 802.11 its eight).The problem is when transmission fails due to congestion in network which may be a temporary failure node consider it as a permanent link breakage and discovers new rote. This leads to the false link breakage detection.

False route breakage detection creates burden on the network because single link breakage affects multiple flow at a time. Hence route maintenance mechanism is modified with route stability mechanism (RSM) [6]. Reactive routing protocol declare link as broken after 7 retries which is not accurate.RSM use link monitoring in which nodes monitors the quality of link to its neighbours to determine long term performance of the link. In this mechanism link is declare broken only when it is physically broken or it is heavily congested, while irregular transmission failure due to transient congestion is not considered as link breakage.RSM uses two phases are link ideal time estimation and link breakage detection.

1) Link ideal time Estimation:

Link ideal time in [6] provides the percentage of link being ideal in network. This is achieved by keeping track on time period for which medium around the nodes id ideal, it is calculated by node ideal time(NIT).

To calculate NIT network MAC layer checks the status of node at time period T and status of medium using carrier sensing mechanism. If the medium is ideal then degree of congestion is smaller and vice versa. It is given as:

$$NIT = 1 - \frac{T_{TX}+T_{RX}+T_{BUSY}+T_{COLL}}{T} \qquad \text{Eq.6.}$$

Where,

T_{TX} , represents the mean time spent in transmission,
T_{RX} , is the mean time spent in receiving packets,
T_{BUSY}, represents the mean time that the medium was busy due to communication between neighbour nodes and
T_{COLL} , is the mean time spent in collision at the node.

The LIT in [6] is considered approximately equal to the minimum of NIT at two ends. for link (j,k) LIT is given as,

$$LIT(j,k) = \min\{NIT(j), NIT(k)\} \qquad \text{Eq.7.}$$

To obtain LIT node must know node ideal time of neighbouring node too hence, they periodically broadcast the HELLO packet containing node ideal time. An exponentially weighted moving average is used to detect the long-term link inference and smooth out rapid changes, it given as:

$$LIT(j,k)_{t+1} = \alpha * LIT(j,k)_{t-1} * (1-\alpha) measured\ LIT(j,k)_t \qquad \text{Eq.8.}$$

2) Link Breakage Detection:

Link breakage decision in [6] is taken on the basis of link ideal time. When link failure occur average LIT is calculated if this time is above particular threshold level then it is considered that link has been heavily congested and declare as broken, otherwise link is considered as temporarily broken.

D. ***Channel assignment algorithm:***

To increase the capacity of wireless mesh network multi radio routers are deployed by assigning non overlapping channels to them. Static and dynamic channel assignment is use to allocate channel to radios. However the channel assignment may result in change of network topology and this affects the performance of network in three ways: first it affects existing flow of network, second when there is node failure some portion of network becomes unreachable due to network partitioning and finally it results in longer routes between node pairs.

Krishna N. Ramachandran, Elizabeth M. Belding, Kevin C. Almeroth, Milind M. Buddhikot in [16] presents a centralized interference aware channel assignment algorithm. This algorithm makes use of all available non overlapping channels and reduces interference within mesh network and between mesh network and co-located mesh network. Advantages of this strategy are that by choosing alternate path around fail node network partitioning is avoided. This strategy avoids the changes in network topology, and finally disruption in flow can be avoided by redirecting the flow over default radio until channel assignment completes.

The mesh network model shown in figure 6 have stationary routers and these routers are equipped with multiple 802.11 radios such as 802.11a, 802.11b or 802.11g [16].All the routers in network assign each of their radio to default radio interface and tune it to the common channel throughout the network. This default channel carries both control and data traffic. Here routers are divided into two types: multi-radio (MR) and single-radio (SR) routers. Channel assignment server located with gateway provides channel assignment reduces interference between routers.

1) Interference estimation:

Channel assignment server keeps IP address of range or exhaustive list of all radios in network and it first checks the two main conditions:

1. link exists only if two radios are assign to the same channel.

2. link in a direct communication range must be tuned to a non overlapping channels,

Then to detect interference it checks the interfering radios on each channel supported by each router. These interfering radios are visible to the router but external to the mesh and are failed in a frame check sequences (FCS) checks done by CAS. Here mesh router uses one radio to capture a packet and these packets are used to measure interfering radios and per second channel utilization. Packet size and rate at which packets are sending is considered to detect interfering radios.

It is necessary to check the amount of traffic generated by the interfering radio because, two channel may have same number of interfering radios but any one channel have heavy traffic load this channel must be avoided. Hence channel bandwidth utilization is done for each channel. The overhead of MAC layer is counted to determine utilization of channel.

E. Congestion aware routing:

In wireless mesh network most of link failure due to congestion in wireless link. Congestion aware routing is based on packet loss differentiation. To differentiate between the real link failure and failure causes due to congestion i.e., temporary failure CAR continuously monitors surrounding congestion and frequency of link failures. It uses link failure count, congestion factor and congestion limit to detect poor quality link and good quality links. CAR provides higher throughput and low routing overheads.

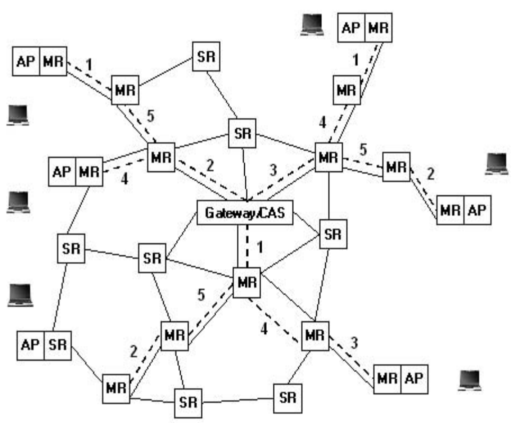

Figure 6. Multi-Radio wireless mesh architecture.[16]

Frequent route breakage and false link failure are the reasons due to which mesh network faces instability. In a simplified network model [17] the probability of successful transmission of packet of flow f over link i is expressed as:

$$PS_{(f,i)} = 1 - P_{loss\ (f,i)} \qquad \text{Eq.9.}$$

Where $P_{loss\ (f,i)}$ is independent rate of loss of link I over flow f. As number of hops increases PS for one packet can be given as,

$$PS_{(f,m\to n)} = \prod_{i=m}^{n} \left(1 - P_{loss\ (f,i)}\right) \qquad \text{Eq.10}$$

As the number of hops increases the rate of successful transmission of packet reduces [17]. Thus for multi-hop network with congested environment the probability of packet loss and transmission failure increases at high extent and it is inefficient to declare route breakage for every transmission failure. The false detection may lead to lower throughput, higher processing delays and unnecessary route recovery processing packets in network.CAR in [17] intelligently make decision between temporary and permanent link failure. By keeping track on frequency and distribution of link failures CAR avoids a unnecessary link recovery procedure.

1) Congestion Factor:

Congestion factor provides the information of degree contention around a node by virtual carrier sensing. Virtual sensing provides no overhead as packets are not exchange among the nodes.CAR in [17] uses a sensing mechanism in MAC layer which calculated MAC busy fraction for window of w sec. The ratio of time for which node is receiving packet from other node plus time for which NAV is pending due to other node activity to the total window time gives congestion factor for node,

$$CF = \frac{Mac\ Busy\ (NAV) + Mac\ Busy\ (Rx)}{Total\ window\ time} \qquad \text{Eq.11.}$$

2) Congestion Limit:

CAR differentiates between actual broken link and congested or temporary broken linking by selecting a particular threshold. This threshold is selected such as neither frequent breakage is detected nor it will wait for much longer time to declare rote as broken. This threshold is known as CL in [17] and it is define as the number of link failure that can be ignore before declaring link as broken,

$$CL = k * CF \qquad \text{Eq.12.}$$

Where, k determines the sensitivity of route breakage. If k=0 then CAR is 100% sensitive i.e if there is link failure then it is immediately considered as broken and by increasing the value of k false route failure decreases.

3) Link Failure Count:

Link Failure Count (LFC) in [17] is define as number of link failure in w sec.CAR monitors the link failure on every link for particular time so that the approximate relation can be obtain between the failures.LFC is given as,

$$LFC_{(i,j)} = Number\ of\ transmission\ failure\ from\ node\ i\ toj$$

Eq.13.

For every link failure CAS checks that transmission failure is above threshold or not. If it is above threshold then link is declare as broken if not then failure count is incremented and congestion limit is adjusted. Thus CAS provides stable and efficient routing in mesh network.

III. CONCLUSION

The self-organizing capability of WMNs network reduced the complexity of deployment but integration with multiple mesh client and ad-hoc network demands reliability. Thus, this article depicts the issue of frequent link failure in WMNs and their effects on throughput, congestion and energy consumption. The higher failure ratio of link due to the physical and logical interference increases the duplication packets in the network which kills not only the bandwidth but increase the latency in the network. Thus, the used of WMNs for internet access as a backbone network degrade its performance. Thus, many techniques were explored for the detection of link quality and improvement in mesh network performance. However, experimentation results of existing WMNs are below the expectation in performance and many issues need to be resolved such as: link quality, link quality with scalability and reliability, network integration with other ad-hoc network and self-configuration-organization under dense mesh network.

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Authors Profile

Ms. Rucha P. Pawar received Bachelor of Engineering from University of Pune, India in 2013 and pursuing Master of Engineering under supervision of Dr. Vaishali Mungurwadi from GTU in year 2018, Department of Electronic and Communication .Her main area of interest is in Wireless Mesh network.

Vaishali B. Mungurwadi received Ph.D. in the Field of Micro-Electro-Mechanical Systems(MEMS) from Visvesvaraya Techchnology University,Belgaum,India. She is presently principle in Sarvajanik College of Enginerring ,Surat,India.She was director of Laximi Institute of Technology,Sarigam,Gujarat. Her professional interest include research in enginnering education apart from technical feids namely MEMS,signals and systems, Digital Signal Prosessing and Digital system Design.

Pranav Lapsiwala received Ph.D. degree from RTMNU, India in 2015. He is currently associated professor with department of Electronics & Communication engineering in Sarvajanik College of Engineeringg & Technology which affiliated with Gujarat Technological University. His area of interest is optical-wireless network, wireless mesh network, ad-hoc network, protocol development for wireless network.

