MAC and Routing Layer Supports for QoS in MANET: A Survey

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ABSTRACT
In Mobile ad hoc networks (MANET), Providing QoS guarantee is difficult task due to unreliable Wireless nature of Link, Mobility, Lacking of Centralized Coordination and Channel contention. For Real-time applications (such as video, audio) QoS is More important on transmissions. Many efforts are put on ad hoc networks at both the MAC and routing layers Meanwhile, QoS aware issues are considered in both MAC and routing layers for ad hoc networks. However QoS can ensure by Admission control protocols and reservation mechanisms. This paper aims to investigate factors affecting QoS, admission control protocols, QoS routing protocols, reservation mechanisms, and MAC Layer QoS Supports. This is also aims to provide deep view of QoS in MANET Of current and Future trends.

Keywords
QoS, Admission Control, MANET

1. INTRODUCTION
The Interesting thing of MANET [1][2] is self-organized Network where ever been proposed in existing networks. MANET capabilities are expected to become an important part of overall Next generation wireless networks functionality's. A Mobile Ad Hoc Network, also called a MANET, is an autonomous collection of mobile nodes able to communicate with each other over wireless links forming a dynamic wireless network. The administration of such a network is decentralized, i.e. each node acts both as host and router and forwards packets for nodes that are not within transmission range of each other. A MANET provides a practical way to rapidly build a decentralized communication network in areas where there is no existing infrastructure or where temporary connectivity is needed. This property makes these networks highly flexible and robust. In these kinds of network practical design issues are there like, Limited bandwidth, Dynamic nature of topology, decentralized coordination. Due to these problem affects the quality factor like, Bandwidth, Delay, Jitter, Its leads the quality of service. For real time applications, such as audio and video needs Quality Of service. In MANET QoS is one of the open issues [3], in recent years many research are going in this area.

QOS is the performance level of service offered by a network to the user. The Goal of QOS is to achieve a more deterministic network behavior so that the information carried by the network can be better delivered and the resources can be better utilized. QOS routing is the process of providing end to end loop free paths to ensure the necessary QOS parameters are met. Generally the parameters that are important for providing QOS are: bandwidth, delay, jitter, battery charge, processing power, buffer space providing different quality of service levels in a constantly changing environment will be a challenge. The inherent feature of communications quality in a MANET makes it difficult to offer fixed guarantees on the services offered to a device. An adaptive QOS must be implemented over the traditional resource reservation to support the multimedia services [4].

In MANET QoS Frame work [5] which mainly include MAC and Routing layer supports. MAC Layer has the components to support QoS,. Mode of operation at MAC layer of IEEE 802.11 is either DCF [13] or PCF. DCF provides best effort service while PCF mode designed for real time traffic support in infrastructure based wireless networks. For supporting real time traffic in AD hoc Network, the IEEE 802.11 Task Group e is enhanced the standard, and found new mode of operations (EDCF,HCF)[15]. Cluster TDMA] also supports real time traffic in Ad hoc wireless networks; this manages bandwidth resources constrain efficiently. MAC Layer support for QOS, in terms of bandwidth reservation and real time traffic supports capability ensures at link level only, in network layer ensures end to end resource reservation. In MANET many QoS routing protocol proposed past and recent years, these kinds of routing protocol ensures various QoS constrains. IN the part of QoS supported routing protocol, includes various strategies like Admission control, Resource reservation, Scheduling. These strategies can improve the performance level in terms of higher throughput, lower delay.

The rest of this paper is organized as follows: In Section 2, we briefly discuss the related work in this area. In Section 3, we describe Challenges providing QoS and QoS related metrics explained in detail. MAC layer solutions and Supports are explained in Section 4. In Section 5 Various Routing layer supports are explained in details. Finally, Future works are given in Section 6.

2. RELATED WORKS
In Recent years many of research is focus to the provisioning of QoS in MANET. Chakrabarti and Mishra [5] later summarized the important QoS-related issues in MANETs that were in focus around 2001. There are some surveys related to QOS provisioning in Mobile ad hoc networks where Chakrabarti and Mishra [6] published in the year of 2004, Al-Karaki and Kamal published a detailed overview about the development trends in, the field of QoS routing. Another survey about the issues and solutions pertaining to QoS in a mobile ad hoc network is presented in Reddy et al. Detailed survey of QoS In MANET were found in Zhang and Mouftah (2005) and Hanzo and Tafazolli (2007). The survey presented in Zhang and Mouftah (2005), discussion on problem provisioning QoS and solutions reported in literature. The survey presented in Hanzo and Tafazolli (2007) list outs the Design consideration, factors of QoS, Layer wise solution

for QoS in MANET [7]. In this paper, we describe in detail survey of QoS in MANET. We gather several papers related to QoS in MANET that appears in referred journals, Proceedings, conference. This survey may helpful for researcher in this field to understand the concepts of QoS in MANET

3. PROBLEM FOR PROVISIONING QOS IN MANET

The unreliable wireless Channel: The nature of high bit-error rates of wireless connection might be more profound in a MANET. One end-to-end path can be shared by several sessions. The channel over which the terminals communicate is subject to noise, fading, and interference, and has less bandwidth than a wired network. In some scenarios, the path between any pair of users can traverse multiple wireless links and the link themselves can be heterogeneous. Packet error can overcome by forward error correction, retransmission technic [6].However packet errors can increases to link failure, leading to rerouting, lower throughput, higher packet delay, and packet dropping due to congestion.

Lack of centralized coordination: The main feature of MANET is instant infrastructure that is it may be formed spontaneously without any proper planning. In this kind of networks is dynamic nature and be connected via multihop routes. Since there is no background network for the central control of the network operations, the control and management of the network is distributed among the terminals. The nodes involved in a MANET should collaborate amongst themselves and each node acts as a relay as needed, to implement functions e.g. security and routing. In MANET, each mobile terminal is an autonomous node, which may function as both a host and a router. In other words, besides the basic processing ability as a host, the mobile nodes can also perform switching functions as a router. So usually endpoints and switches are indistinguishable in MANET. This increases the complicity and overhead [5].

Channel contention: In route discovery phase needs the common channel, nodes in a MANET use the MAC protocol to find the common channel. Especially IEEE 802.11 Distributed coordination Function (DCF) introduces the problem of interface and channel contention. Hidden and exposed node problems are also of channel contention [5]. These problems can increase the network collision and reduces the network capacity. For example in hidden node problem tow data session being forwarded on routes within the interference range of each other reduces the channel capacity of the available node.

Dynamic Network topology: The topology can be varies due to mobility, since path break can occur frequently. Once path break can happen immediately need to reconstruct path, due to this network congestion can leads. Route failure can also induce channel errors. A transmitting node may move in to another sensing range of another transmitter, thereby increasing its interference. The admitted QoS session may suffer due to frequent path break, thereby requiring such session to be reestablished over new path. The delay due to path reestablishment may increase the packet drop, which is not acceptable in the case of QoS requirements. The routing protocol can suffer for frequent reconstruction of route [6].

3.1 QoS Metrics

The QoS metric of various layer is given [7] in details, which emphasize the quality constrains. The metrics given is most important while evaluating the protocol performances. In this section we discussed QoS metric to be considering in Physical layer, MAC layer, and network Layer. The protocol performance mostly relies on these layers.

Physical Layer

• ***Signal-to-interference-noise ratio (SINR):*** This metric ensures that quality of link between sender and receiver, the receiver station can be used SINR [8] to estimate the signal quality based on received signal strength indicator (RSSI)

• ***Bit error rate (BER):*** This physical layer metric ensure that level of error correction and number of retransmission require a link. This impact on link reliability and energy consumption.

• ***Battery Power:*** The residual battery charge may be estimated by measuring the voltage of the battery and comparing this to the battery model's discharge function. Examples of use as a routing metric;

Data Link Layer

• ***MAC delay:*** The time taken to transmit a packet between two nodes in a contention-based MAC, including the total time deferred and the time to acknowledge the data [56]. This provides a good indication of the traffic load in the vicinity of the communicating nodes.

• ***Local residual capacity:*** The most common method of estimating this metric is by monitoring the channel idle time ratio (CITR) [9], the CITR may be multiplied by a link's transmission rate to estimate the link's residual capacity. Another method is to use the reciprocal of the MAC delay that is incurred when forwarding a known number of bytes. However, note that the CITR only estimates the sensing node's transmission opportunities, while the reciprocal of the MAC delay [10] considers the receiving nodes as well.

• ***Link reliability:*** The statistically calculated chance of a packet or frame being transmitted over a link and being correctly decoded at the receiver. An alternative to this metric is to measure the average number of re-transmissions required to successfully deliver a packet to a particular neighbor node. The direct measurement of the collision rate through the use of beacons can also be applied

Network Layer

Since the network layer is the layer of end-to-end connections, the corresponding metrics can often be mapped directly from the user-species requirements [11]

• ***Average throughput:*** This is the average number of data packets received by the destination node per second.

•***Average delay:*** This is the average overall delay for a packet to travel from a source node to a destination node. This includes the route discovery time, the queuing delay at a node,

the retransmission delay at the MAC layer, and the propagation and transfer time in the wireless channel
.

•***Routing overhead:*** It is the average ratio of routing-related transmissions to data transmissions.

•***Bandwidth Bound:*** Minimum rate at which packets can be transmitted.

•***End-to-End Network Delay Bound:*** Maximum time a packet takes to reach from source to destination.

•***Delay Variance Bound:*** Maximum time difference between arrivals of two consecutive packets at destination.

•***Packet delivery ratio:*** ratio of number of packets reaching destination to number of packets sent by source. It specifies threshold for performance evaluation.

3. MAC LAYER SOLUTIONS

3.1 Modes of Operation in IEEE 802.11x

IEEE 802.11 Standards, Defines two modes of operation in MAC protocol [12], namely Distributed Coordination functions (DCF)[13] and Point Coordination Function (PCF) [ref]. Which basically offers the services of distributed and centralized manner. For providing QoS the IEEE 802.11 Task Group e (TGe) have been setup Enhanced Distributed Coordination Function (EDCF)[15] and Hybrid Coordination Function(HCF)[ref]. For coming Sub title we focus to discuss on PCF, DCF as well EDCF and HCF.

A.Distributed Coordination Function (DCF):

In the most wireless LAN technologies are included in this kind of operation. In which operations are done distributed manner. DCF does not provide the guarantee QoS, because DCF allows accessing the channel simultaneously [14].In this mode of operation uses CSMA/CA and random back off scheme are used to reduce collision. If sender wants to transmit data to receiver, sender start listens the channel , if channel is busy it waits until channel become ideal sender station waits for DIFS (distributed Inter Frame Spacing) time periods and invokes backoff procedure back off time can be calculated by

Back-off Time= rand(0, CW) x Slot Time

slot time includes propagation delay and transmission delay, congestion rate can be set at the initial rate of Cmin and its expands up to C max if congestion gets increases. When the node detecting channel become ideal for DIFS time periods sender station starts to decrease the back off counter. When back off counter become zero RTS (Request to send) and CTS (Clear to send) negation can happen and after that data (MPDU) transmission take place. MPDU is MAC Protocol Data Units is offered in MAC layer data structure offered in IEEE 802.11

B. Point Coordination Function (PCF)

In DCF mode of operation, operations are done in distributed manner. There is no control over there. Where as in PCF mode has the centralized modes of operation, hence its supports QoS services. But in the case of PCF designed for infrastructure based networks. A station wants to transmit PCF mode, it has to get association identifier (AID) from PC (point coordinator). The role of PC is determined which station should gain access to the channel. The PC generates a beacon frame called Targeted Beacon Transmission Timer (TBTT), which maintains synchronize among local timers. The PC uses the pollable, before transmission begins. If PC remains no response in PIFS periods, it polls to next station.

C. Enhanced Distributed Coordination Function (EDCF)

It works both functionality like distributed as well as differentiated services, when MAC layer receives the higher layer data’s (frame), which contains the user priority (UP) and it maps to access categories (AC). AC contains different priority level of accessing the wireless medium. Here in EDCF access categories are defined up to eight categories [15]. To access the AC, EDCF defines access parameters like in DCF, that parameters are Cmin, Cmax, AIFS (Arbitration Inter Frame Spacing) and transmission opportunity time(TXOP), TXOP is defined as an interval of time duration which a station has right to initiate transmissions. During contention periods (CP), each AC of station contents for a TXOP and independently starts a back off counter after detecting the channel become ideal for AIFS time periods[16]. AIFS is set as given below

AIFS[i] = SIFS + AIFS.N[i] x slot time

AIFS.N- Slot count

i-is a Priority class

3.2 MAC Protocols

The classification of MAC protocol is divided in to three categories that is, contention free, contented based, independent [7]. In contention free MAC protocol, resources are identified first and then it reserves the resources. Since that it can free to transfer the data’s. It basically uses the TDMA for slot allocations. These kinds of protocol provides Hard QoS guarantee (Hard QoS generally used in wired networks) in MANET. In contended MAC protocols estimates the statistical data of the available resources. In this contended based MAC protocols ensures the soft QoS guarantees. This maintains the implicit reservation mechanism so that session admission cannot be overlap. In the last category is independent, this do not have any interaction in MAC protocols. They estimate node state and attempt to route using those nodes for which more favorable conditions.

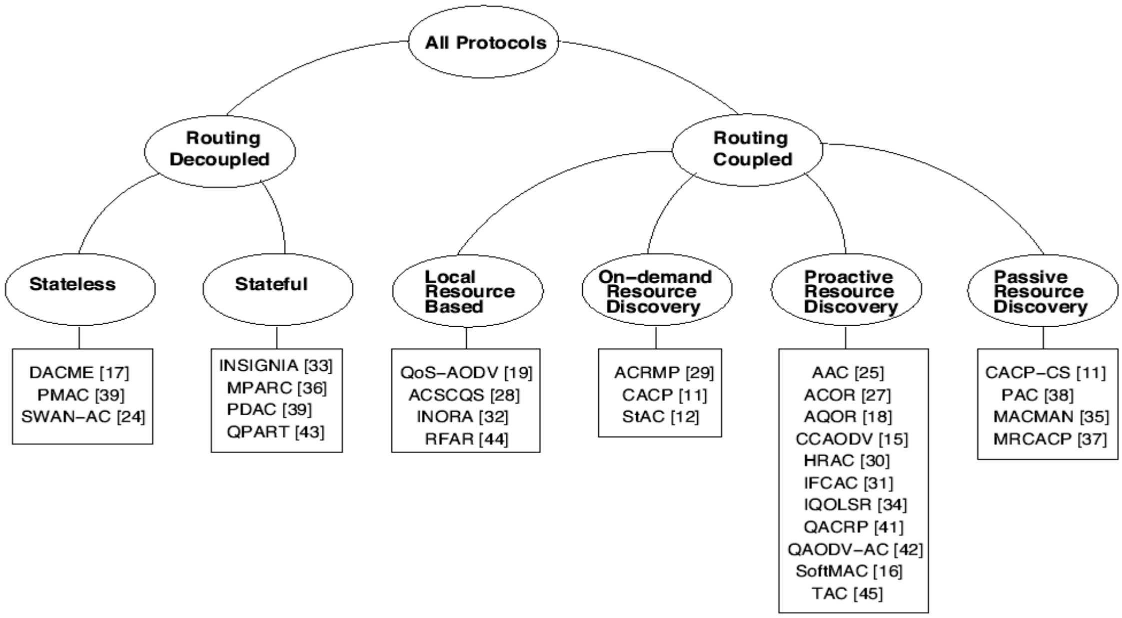

Fig 1: Classification of admission control protocols

4. NETWORK LAYER SOLUTION

4.1 QOS Routing

The goal of QoS aware routing protocol is to determine the QoS constrain while constructing a route. In general QoS constrain is Bandwidth, delay, jitter. Since that routing protocol itself ware the QoS constrains. In the literature, many protocols have been proposed [17]. In the following section QoS routing protocols are described. Routing protocols can be classifieds in to three categories viz, proactive, reactive, hybrid routing protocols [7]. These calcifications are made by based on routing information's. Proactive routing protocols is detect the path before the transmission begins, ie. Routing table can be update at every frequent of time. Routing table can be maintained in every node. Since that route requirements asked by the node means it immediately provides the route [19]. In these types some of routing protocols are QOLSR (QoS Optimized Link State Routing) and PLBQR (Predictive Location-Based QoS Routing in Mobile Ad Hoc Networks). In reactive routing protocol, the routes can be determined when the node wants the routes. This routing protocols are also called as on demand routing protocols.in this case route maintenance is so important, means that when route failure happens route has to reconstruct. In these type some of the routing protocols are QoS AODV (QoS Ad-hoc On demand Distance Vector)[18], ACMP (Adaptive Core based Routing Protocol with Consolidated Query Packets) and CQMP (Mesh-based Multicast Routing Protocol with Consolidated Query Packets) are typical examples for reactive routing protocols. In reactive routing protocols have some advantage like low control overhead. In hybrid routing protocol contain the both functionality of proactive and reactive routing protocols.

4.2 Admission Control

Admission control mechanisms is used to estimate the state of the network's resources and thereby to decide which application data sessions can be admitted without promising more resources than are available and thus violating previously made guarantees. The purpose of AC is either to admit only those data sessions whose QOS requirements can be satisfied without violating those of previously admitted sessions. Admission control mechanisms basic functionality is estimating resources and contention for the resources. The AC mechanism decides to admit or reject a session based on the available resources and the contention for the resources [20]. In admission control need additional mechanism for an admission decisions, means that it ensures that the resources are available for transmissions. This procedure can be done in the time of route discovery. Interesting thing in admission control protocol is, this procedure can done by QoS aware routing, while discover the route at the time it ensures the resource capabilities. The admission control protocols can be classified in to several ways given in fig 1. firstly admission control coupled or decoupled with routing protocols. Second classification can be based on state i.e., state full or stateless. Third is based on QoS Constrains. In the case of decisions being based on resource state discovery, this can be achieved either on-demand, periodically in a pro-active manner, or continuously in a passive manner [21]. Achievable QoS relative to its requirements. Such predictions may, in turn, be based on the observed QoS of previously admitted sessions, the QoS experienced by probe packets traversing a route, or the states of the resources of both the nodes on the route and those neighboring nodes (cs-neighbors) that would be directly impacted by the session's admission.

4.3 Scheduling

The nature of MNET induces the mobility, in this at most of the time path can be broken. The frequent packet transmission needed a scheduling algorithm to determine which packet to proceed next so that it increases overall network performance when traffic load is high. Scheduling algorithms is also a key factor to increase QOS in MANET. Scheduling algorithms are explained in [22] details. The current researcher uses the priority scheduling algorithm for simulation. In the interface Queue data packets are schedule in FIFO order and routing packets scheduled in priority algorithm. The routing protocols uses the different scheduling algorithms, the dop-tail policy is used as queue management in all scheduling algorithms. If buffer is full drop-tail Policy is used to manage queues. In the view of priority is given to control packets rather than data packets, Except for the no-priority scheduling algorithm, all the other scheduling algorithms give higher priority to control packets than to data packets. Network traffic can be classified into two categories: control packets and data packets. Scheduling can be classified in two categories: Packet scheduling and Channel Access Scheduling. Packet scheduling deciding the order in which packets waiting for transmission at any node must be dispatched. Channel Access Scheduling decides how different nodes share a channel in a contention region [23].

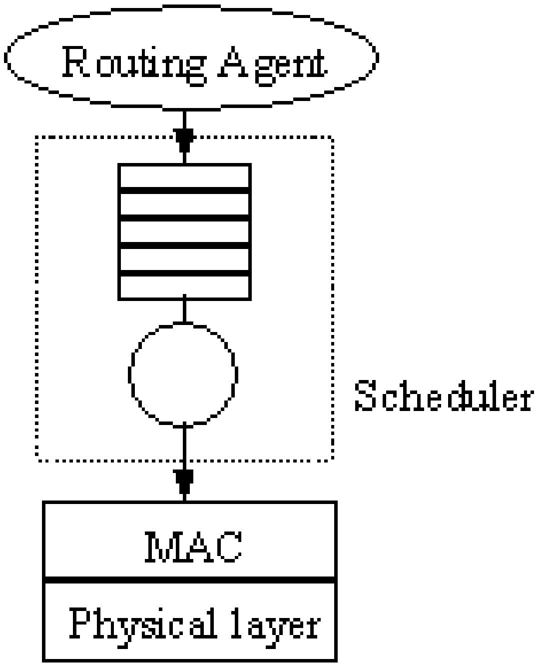

Fig 2 : A mobile node. The scheduler is placed in routing Module.

In the diagram given in fig.2 explains about scheduler jobs in the network layer and where it has been placed. The part of network routing agent scheduler works as follows, in the first step it accept the network traffic from the routing agent and place in to buffer. In the second step scheduler schedules the packet according to its arrival rate of the Queue. Since scheduler regulates the traffic and also prioritize the traffic packet. Various scheduling algorithms are discussed in the following sub titles.

i) No-priority Scheduling

In non-preemptive scheduling algorithm service are done in First in First out (FIFO) order, therefore we cannot achieve the QoS. When the traffic is prioritized, we can achieve level QoS. Non priority scheduling discipline services both control and data packet in FIFO order, there is no preferential treatment for data and control packets.

ii) Priority Scheduling

In the recent paper all most discussed about priority scheduling. MANET researcher uses the priority scheduling to achieve increased level of performance. It maintains separate queue for both control and data packets, it follows FIFO order. High priority is given to control packets.

iii) Weighted-hop scheduling

The data packet who has the lower hop count to reach its destination is given to higher priority. The packet that needs fewer hops to traverse, have more potential to reach its

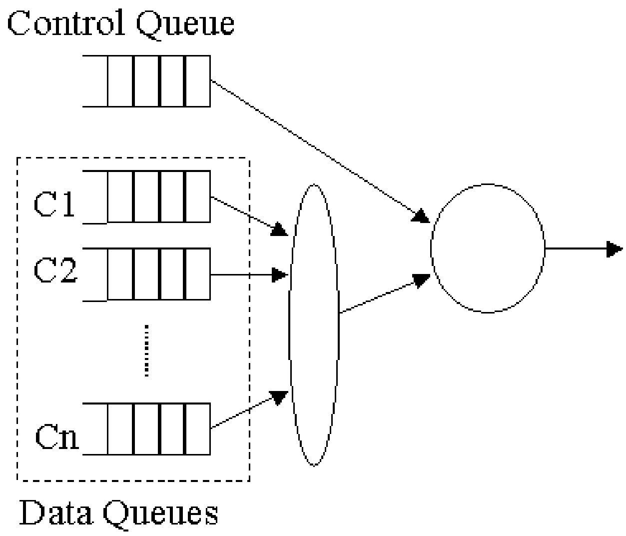

Fig 3: Packet scheduler

Destination quickly and incurs less queuing in the network. This mechanism works by round robin fashion, so that all kinds of service chances are given to every path of transmissions. This avoids starvation, by weighted round robin scheduler. In the fig.3 The data queue of the class CLi maintains data packets whose number of remaining hops to traverse is i. When the number of remaining hops of a data packet is greater than n (the number of data queues), the data packet is classified as CLn. For example, if the remaining number of hops of a data packet is 2, it belongs to CL2. The data queue of the class CLi receives weight Wi ($1 \le i \le n$). Each data packet header carries a complete list of nodes through which the packet should travel. The remaining hops can be obtained to traverse from the packet headers. In routing protocols except DSR, this information can be obtained from the routing table, which stores the remaining hops to destinations.

iv) Weighted distance Scheduling

The weighted-distance scheduler is also a weighted round robin scheduler. It gives higher weight to data packets that have shorter remaining geographic distances to the destinations. The remaining distance (Remaining Distance) is defined as the distance between a chosen next hop node and a destination [23]. Class CLi is determined by the virtual hop, Virtual Hop is calculated by Remaining Distance Plus one Quantization Distance. Where Quantization Distance is a distance for mapping the physical distance into the class. When the Virtual Hop of a data packet is greater than n (number of data queues), the data packet is classified as CLn.

v) Round Robin Scheduling

Round robin scheduling maintains flow of queue, which send one packet at a time in each flow of queue. Round robin queue maintains per flow queues, and flows are identified by source and destination pair address.

vi) Load-based Queue Scheduling

In this algorithm, priorities are assigned to node that its level of load. When load is less on the node which helps to construct the route to other node otherwise simply avoids the construction of the routes. Node's load level can be calculated by queue length, in this load indicated by threshold value of Min and Max. if load indicates low means threshold value can set in to Min and load is High its set in to Max. Scheduling is divided in two steps: Scheduling policy and Dropping Policy [24].

vii) Cluster-based multi-channel Scheduling:

The cluster communication can do it process by two ways one is intra cluster communication and another one is inter c cluster communications. TDMA can help to improve throughput and QoS in cluster communications by allocating a fixed time slot per packet to each node over multiple channels. In the intra-cluster communication, packet transmission of each cluster member is processed within its cluster. Each cluster member has a packet to a random destination. If its packet destination is located within the same cluster, it transmits the packet to the destination directly (i.e., direct link). Otherwise, it forwards the packet to its own cluster head in order to save battery energy (i.e., uplink). On the other hand, in the inter-cluster communication, each cluster head broadcasts packets received from its members to their destination over specific channels of their destination similar to broadcast scheduling methods [23]. The objective of cluster-based multi-channel scheduling algorithms is to maximize the end-to-end throughput by optimizing the number of total TDMA slots in the cluster communications.

viii) Channel Aware Packet Scheduling

Channel aware packet scheduling algorithm can ensure the channel congestion and also path life time. During the route discovery, the path congestion and life time can calculate and it stored .This path lifetime value is used as a parameter to represent the end-to-end channel condition. During packet scheduling, selects packets, which has high probability of reaching the destination, and takes into account the cost of a link break by giving priority to flows that have a longer normalized (with path residual lifetime) backlog queue[26].

6. FUTURE WORKS

In MANET especially QoS what observed is, to provide QoS in MANET we need to focus on admission control, Scheduling Mechanisms, and reservation Techniques. Routing coupled with admission protocol will give the better performance than the other. The QoS Routing protocol must aware about the route nature and also admit the session according to that. Session admission is so important in QoS, hence we can achieve the desired amount of QoS.

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