INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH & DEVELOPMENT

ISSN 2278 – 0211 (Online)

QoS Based Network layer and MAC Layer in MANETs: Metrics, Issues and Challenges

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Abstract:
Mobile Ad Networks is a class of self configured , infrastructure less networks. It basically represents complex distributed systems comprises wireless mobile nodes that can freely and dynamically self-organize into arbitrary and temporary , "ad-hoc" network topologies. Quality of service support is a very challenging task in MANETs because of time varying link capacity , limited bandwidth , and the most important of all is dynamic topology. Thus when it is even difficult to trace the route between mobile source node and mobile destination node , it actually becomes very difficult to locate and maintain the routes satisfying one or more quality of service constraints. This paper attempts to present some of the prominent Metric and Issues related to Network layer and MAC Layer Then the researchers also proposed a modification to the existing algorithm initially given by Wen-Hwa Liao [4] in the way by merging sending table (STx) and receiving table (RTx) per node as merged sending – receiving table (STRTx) per node , to further improve the performance of bandwidth reservation QoS routing protocol for mobile ad hoc networks .

Keywords*: Quality of Service (QoS) , MANETs (mobile ad hoc networks) , load balancing .*

1. Introduction

A Mobile Ad hoc Network (MANET) is an autonomous system that consists of a set of identical mobile nodes that move independently and freely. It is actually a collection of wireless mobile nodes that dynamically form a temporary network without the use of any existing network infrastructure or centralized administration [8] . Because of rising popularity of multimedia applications and the requirement of being connected in the world of mobility it is a crucial factor to focus more and more to bring out the better service if best is not possible , ubiquitously . Hence the need of the hour is not only to provide the connectivity but to promise the service following the paradigm of quality depending upon the requirement of application and availability of resources. But aforesaid environment of MANETs talks all about the scenario of continuous motion of nodes which are already hoaxed by a slew of problems like limited transmission power , hidden exposed problem , continuous mobility of nodes , thus leading to dynamic topology , which again lead to frequent making and breaking of connections with mobile nodes (as the world is mobile or following random way point model in which nodes moves and pauses for a certain amount of time), limited battery (as nodes are battery operated) , time varying link capacity , limited bandwidth , overhead. Overhead is not only associated with route discovery , reply with acknowledgement of route and route maintenance between source and destination but also first locating the position of neighboring nodes for synchronization through which traffic is to be relayed to its destination , thus either we need to install GPS or beacon the " Hello " messages frequently. These are the problems normally faced in MANETs even when we did not talk anything about the quality of service . Thus now it could very well be imagined that how difficult it is to assure the quality oriented service in the ambience of mobility where every node is moving through which service is to be assured and implemented . In this paper authors present a brief study of routing protocol based on QoS and then modification is proposed in the QoS routing protocol as given by Wen-Hwa Liao [4]. Rest of the paper is organized as follows sec ii describes issues for QoS support in MANETs , sec iii presents the QoS model , sec iv discusses the metrics and issues of network layer sec v. discusses Medium Access Control layer metrics issues

based on quality of service , sec vi. overviews the modification in TDMA based QoS in MANETs , and lastly sec vii. depicts the summary and conclusion drawn.

2. Issues for QoS support in mobile ad hoc networks

- Multipath routes : Discover the multiple paths or routes so that in case one route fails another route easily take its place without causing much delay to the application .Thus adds the reliability to the network .Also when a *route is selected , the prediction of link and route failure shall be taken into account.* According to priority of the application a no. of backup routes should be used for reliability backup.
- Decide the parameter (k) indicating the no. of neighbors to whom to forward the QREQ message . So there can be various criterias of successfully selected the neighbors for forwarding the QREQ (RREQ messages demanding some quality of service) message like more available time slots , less mobility , less error rates and more reliable links . The value of k can vary depending upon success rate of previous routes discoveries.
- QoS routing protocol not only discover and reserve routes but considers those path that meet certain constraints like fulfilling bandwidth , delay , variance in delay (jitter) and error rate and also we can have *sequential filtering* means applying one constraint after another.
- Discovered routes must be stable so as to satisfy the stringent requirements of QoS in multimedia and real time applications.
- Expanding TTL (time to live) for route discovery . Initially take TTL as small , if route is not discovered in that period then slowly increase the TTL time.
- Traffic differentiation and prioriterization : For a real application or high priority traffic , existing routes are either discarded or preempted if they don't hold fit for current multimedia applications.

3. QoS Model

With the emerging technology of multimedia applications and its usage in civilian life interest has been awakened many folds in providing QoS support in MANETs . QoS may be defined as *" the set of service requirements that needs to be met by network while transporting a packet stream from to its destination"* .It's a challenging task to get quality of service in MANETs considering this many researchers have been done and are still continued [8] with the goal of achieving or providing quality of service [8] .Most of the proposal differ in the approach used for searching a new route and / or modifying a known route due to the frequent movement of hosts and not in power to further relay the traffic because each node has a limited range with in which it could act as a transceiver. Basic model of ad hoc network depends on "Best Effort " basis and does not assure any guarantee of QoS [Crawley 1998] .Later on a flexible Quality of service model (FQMM) for mobile ad hoc networks was proposed by Hannan XIAO inc. as a part of national R&D centre , CWC (Centre for Wireless Communications). In this model a hybrid approach is proposed considering per flow as well as per class provisioning .In this approach traffic of highest priority is given per flow provisioning while other priority classes are given per class provisioning . The proposed model introduces three types of nodes as ingress node (source node) , interior node (relay node) and egress node (destination node) . FQMM has service differentiation thus per class provisioning could further be improved to per flow provisioning for certain classes of traffic [8]. However it is difficult to provide per flow granularity to all the traffic in a MANET due to bandwidth limitation and other constraints.

- Hybrid approach = Per flow (INTSERV) + Per class (DIFFSERV).

The traffic is conditioned at ingress node based on the bandwidth allocation as the relative differentiation parameter , to differentiate the traffic. Components of conditioner traffic profile meter , marker and dropper .Traffic profile examines the traffic and can be defined as the relative percentage of the effective link capacity , in order to differentiate between classes and to make them predictable and certain.The traffic profiler can be implemented using the token bucket concept .

4. Network layer Metrics and Issues

To provide QoS support in MANETs both MAC layer and Network layer go hand in hand . There can be various network layer issues that are needed to be considered to assure quality of service in to application like path ranking , traffic assignment and traffic adjustment [9] . An integrated routing metric covering both network layer and MAC layer , could be considered to evaluate all discovered paths quality in terms of hop count , congestion bottleneck , no. of congested nodes . Once path ranking is decided for all the routes then traffic is assigned to a route fulfilling the requirement of traffic . If choosen path suffers from congestion at any point of time then traffic adjustment mechanism is called for , so as to (as path_1 , path_2 , path_3 …..) choose the better path . Thus a path list is prepared for a traffic between a source and a destination. Initially path_1 is taken to relay the traffic if congestion is between 0 and set threshold . if after sometime the choosen traffic feels congestion then different path from path list may be tried .Broadly QoS support in network layer can be categorized in three ways .

- QoS routing protocols : In this category providing QoS support is an inherent part of the routing protocol like search for a basic route between source and destination along with satisfying QoS requirements like bandwidth and delay included into route discovery process .
- QoS Signaling : Here in this category first the basic path is searched between source and destination by the routing protocol and then at separate signaling layer , reservation and release of resources is done on previously searched route by routing protocol e.g INSIGNIA .

- Coupling between QoS mechanism and routing protocols : In this framework , the QoS signaling mechanism provides the feedback to the routing protocols about the status of the QoS parameters and may ask the routing protocol for alternate routes , if current one does not satisfy QoS requirement (INSIGNIA + TORA) .

Network Layer Metrics : Following are the various network layer metrics that can be used to measure directly the performance of routing at network layer as [11] :

- End-to-End delay (s) – the measeured end-to-end delay on a path.
- Throughput (b/s) – the amount of data carried along the route.
- Node buffer space – the no. of packets in buffer determines the delay a packet will suffer.
- Jitter – the variance in the delay measured.
- Energy expended/packet – measured in joules .
- Route lifetime – the time for which a route is considered to be valid (after route is discovered)
- Route discovery delay (s) : a measure of how early a source gets a RREP message after releasing RREQ message.

5. MAC Layer Metrics and Issues

Following are the various Medium Access Control (MAC) layer metrics that directly affect the performance of MANETs at MAC layer as [11] .

- MAC delay : time taken to transmit a packet between two nodes .
- Link reliability : it is a measure of chance of a packet transmitted over a link and received at destination.
- Link stability : the predicted lifetime of a link .
- Node relative mobility : it is a measure of no. of neighboring node that change to the no. that remain fixed over a period .
- Normalized MAC load : the ratio of bits of control frames to the bits of user data frames transmitted .
- MAC energy efficiency : ratio of energy used for sending data bits to tha total energy expended for data plus MAC headers and control frames.

There are various MAC layer issues like determining network organization , link scheduling to reserve the slot for each link , buffer management to support routing *as all the reactive protocols like DSR and AODV does not consider the status of route while establishing the route between source and destination* , as even IEEE standard 802.11 does not have the effective provision of traffic or service differentiation or handling node congestion .Thus differentiated services mechanism is needed to be imbibed in MANET so as to assure the quality in services offered by the mobile environment. In these circumstances load balancing is one of the critical parameter to be taken care of at MAC layer . Also a large amount of work has been done on service differentiation through distributed mechanisms like *in case of congestion , sending rate of low priority application is reduced drastically while sending rate of high priority application is reduced by small amounts.* An effective and efficient load balancing technique was proposed by M. Brahma inc. in his paper where in author presents a push out based queue management technique with load balancing capabilities to distribute and efficiently use the resources by differentiating the services to support QoS (quality of service) [5]. In this load balancing algorithm whenever a node feels congested it issues three types of packet (help packet , ok packet and notify packet) to call its neighbor to get rid of congestion. . To manage the *buffer* associated with each node and to make space into full buffer of a node [5] . TDMA (Time Division multiple Access) based QoS routing protocols are also briefed as those in which to reserve the time slots between two nodes considering the slot reservation status of its one and two hop neighbor . A TDMA frame is composed of 2 fields as control phase and data phase . Control phase is responsible for frame synchronization , call set up , call maintenance and time slot reservation .

Based on the constraints given in QREQ message , slots can be allocated uniformly in an assured manner all along the route from a global point of view as following below mentioned steps 1) Find the link that has least no. of available slots (taken as the bottleneck of a route . 2) Decide available slots calculated in step 1 as the bandwidth that can be promised for the taken route hence can be manifested temporarily that is tentative evaluation of a route in terms of bandwidth . 3) Select free slot in its neighborhood first towards the destination and then towards source .Assignment of time slot according to the order of their availability along the links.

6. Modification proposed in TDMA based bandwidth reservation QoS routing protocol

(In a paper written by Wen – Hwa Liao [4] , he proposed bandwidth reservation QoS (Quality of Service)routing protocol for mobile ad hoc networks .When a node wants to trace some route to a certain destination not in its direct vicinity then it sends a QREQ (Request message with Quality constraints) having following fields source node , destination node , b (bandwidth requirement in the form of no. of slot) , path traced so far (initially set as null) , NH (list of neighbors to whom to further forward the QREQ message to) . If the node receives the QREQ message satisfies the b constraints then the message propagates in to surrounding till it reaches the QREQ packet reaches to its said destination . For the concept proposed by Wen – Hwa Liao to implement routing protocol ensuring quality in transmission , it is necessary that each node maintains three data structures as STx [1..n , 1..s] , RTx [1..n , 1..s] , and Hx [1..n , 1..n]

where index [1..n] indicates no. of nodes while the index [1..s] figure out time slots . In this paper researcher is trying to optimize the bandwidth utilization from a global view [4]. But one further improvement is possible thus proposing that inspite of maintaining three data structures we can maintain two data structures by merging Sending Table (STx) and Receiving Table (RTx) combined as STRTx . Each merged table per node contains info. not only about which nodes are sending and receiving in which

slot but also can keep a track of scheduling activities of neighboring nodes and thus accordingly schedule slots for its one and two hop neighbor also help in reusing the slot by nodes which are not 1 or 2 hop neighbor of node for which data structures are being created .The concept introduced although proposed theoretically only but for sure when implemented later will improve the performance and efficiency of the network on the fly seamlessly .

7. Conclusion

Thus seeing today's demand of multimedia applications and need of being always connected may with or without internet is constantly attracting the researchers to further evolve the MANETs in order to assure the guarantee of services in terms of quality although quality parameters may be different for different for different network or application In this paper we have tried to focus on few QoS routing techniques at both network and MAC layer like multipath , path ranking , congestion control , TDMA based and queue management issues that are seriously needed to be handled if quality is to be mandated in the services of the network , which is highly mobile and unpredictable . Keeping this mobile , resource constrained environment into account it is actually a very difficult challenge to accept and implement in terms routing and quality oriented routing and most important of all is maintenance of whatever is discovered . We also proposed a modification into an algorithm proposed initially at [4] algorithm and it is being hoped that a substantial amount of performance is going to be increased in MANETs , at less overhead.

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