Minimum Delay Routing Protocol with Enhanced Mutimedia Transmission over Heterogeneous MANETs

Khaja Anwar Ali Siddiqui
Electronics and Comm. Engineering Department
JBIET[Autonomous],
Hyderabad, India
anwar.jbit@gmail.com

Yousuf Khan Afroz
Computer Science Engineering Department,
Shadan College of Engineering and Technology,
Hyderabad, India
yousufkhanafroz@gmail.com

***Abstract*—Mobile Ad-hoc network popularly known as MANETs, consists of mobile nodes without any fixed infra-structure, where each node actively participates in routing a multi-rate network employs nodes with different data rates, radio range and bandwidth. A heterogeneous MANET has various kinds of mobile nodes. Thus to deliver message from source to destination or to have per-to-peer communication it not only requires a route establishment but also to ensure minimum delay.**

we attempt to analyze various delays involving in packet transmission with mathematical formulation and conditions subjected to certain assumption .This mathematical modeling proves to be sufficient to answer the QoS demands like finding the path with minimum delay among the available paths from source to destination, taking into consideration the route parameters like geographic distance and data rate. Another application is the packetizing (or) packet/cell framing to utilize other paths whose data rates may be degraded, this increase the utility and efficiency of overall network. Minimum delay routing protocol (MDRP) can also be used to determine the routes having same delay though they may differ in terms of geographical distances and data rates. Such approach will be efficient for multimedia transmission over parallel links with minimum delay jitters. Various critical situations have been solved using proposed techniques as examples to validate the protocol.

Keywords-multi-rate MANETS, Bandwidth, processing-delay, queuing-delay, transmission-delay, propogation delay, gerogarpic-distance, data-rate, mutimedia QoS conditions.

I. Introduction

A mobile Ad-hoc network [1] consists of mobile nodes, making the network topology to change rapidly and randomly. Routing between nodes that are not directly within each other's transmission range is performed by the intermediate mobile nodes which are connected by wireless links with maximum coverage up to 2000 meters [2,3],since MANETs have no centralized administrative support. Examples of such networks are note-book computers, personal data assistances (PDAs) in a conference, rescue operations, disaster management etc., where a speedy communication is desired. The specific characters of MANETs include *mobility of nodes, bandwidth availability and battery operated intermediate nodes*. Moreover, the 802.11 a/b/g/e standards have data rates ranging from 1 to 54 Mbps. However to use these multi-rate capabilities, the routing protocol must be aware of such network information [4].The present routing algorithms can be broadly classified into two categories, *Position based routing protocols* and *Topology based routing protocols* [5].The position based routing protocols are efficient in the sense that they have a lower route discovery overhead as compared to proactive and reactive topology based protocol, which floods the network. The route from source to destination is established by utilizing location Service of the GPS modems attached to each node which helps the node to be aware of its position and position of neighboring nodes. In *greedy forwarding based protocol* a route from source to destination is assigned in terms of shortest geographical distance between source and destination without conforming the compatibility of assigned route for message size which is to be sent from source to destination.

Our proposed technique focuses on Position based geometric routing, where the source nodes knows the position of the destination node. To establish a route with minimum delay, we will calculate *End-to-end delay* with its mathematical formulation. The analysis of such formulation will be used to assign routes for an efficient multimedia transmission via parallel links and efficient framing of the data to utilize the available paths effectively reducing the power consumption.

The rest of the paper is organized as follows. Section 2, gives an overview of related work. Section 3 presents our proposed approach. In Section 4, we deal with some topologies to validate our approach. Conclusion is presented in Section 5.

II. Related Work

A recent approach to delay minimization is made by the author [6, 7, 8], where *Genetic Algorithm* is used to establish a route to assure minimum delay for the message delivery. In this algorithm, to assure least delay, each set of nodes should minimize the *fitness function* and the formulation of fitness function is based on minimizing the sum of network parameters like *processing delay, distance to next node, and bandwidth availability at the nodes, mobility ratio, and hop count for the route.* But the addition of such unlike quantities lacks a formal proof and accuracy.

The previous approaches includes an improved version of AODV routing protocol [9] based on the link cost for multi rate MANETs. Where each node transmits a repeat request

[RREQ] with a predefined time to live. Every RREQ is identified by its sequence number. The first received RREQ is processed and the duplicates are discarded. This process is repeated for reverse path update. But such regular path updating causes network flooding, so many generated RREQs may loss and route discovery procedure may not perform well. Since RREQs are avalanche patters. Another approach [11] is presented as QAODV (Quality of Service AODV) to improve the delay in using AODV when distances between nodes are closer. The approach is based on only bandwidth as a parameter for routing. However bandwidth may not be sufficient to address QoS for real-time applications where delay jitters are acme.

For an efficient multimedia transmission, Asif[3] proposed an approach. In which the author focused on delay minimization for video streaming with H.263 and H.264 based models. But neglects propagation delay, processing delay, transmission delay. Since, transmission delay depends on data rate, so it is necessary to consider such delay for Heterogeneous MANETs.

Our proposal is based on End-to-end delay formulation. This can be solved to estimate a minimum delay path. The proposed delay equation maps network parameters such formulation will be efficient for multimedia transmission over parallel links with different data rates between two Proposed Approach.

In order to calculate the path with maximum throughput, we considered *End-to-end delay*. Which is the sum of *total nodal delays*, which in turn is given by *processing delay, queuing delay ,transmission delay and propagation delay* at each node.

A. Impact of Delay on Transmission

Delay while establishing a peer-to-peer communication is the sum of total nodal delays of all the intermediate nodes it is the time taken for a packet to be transmitted across a network from source to the destination.

Total nodal Delay

The time consumed at the node for receiving the packet and passing it to the upstream router after queuing it constitutes nodal delay.

Total nodal delay=processing delay + queuing delay + transmission delay + propagation delay.

Processing Delay

The time consumed in determining the packet header and examine where it should be directed is termed as *processing delay*. If the packet is to be directed through the the node then it is queued inside the nodal buffer .This delay is limited to few microseconds (µs).However packet will not be processed, unless and until all of the packet's bits were not received. We will be using this property, while packet framing for specific routes. For multimedia transmission it is the sum of *compression and decompression delays*.

Queuing Delay

The time spent for being in the queue waiting till the packets arrived before gets transmitted, constitutes queuing delay. This is zero for a packet arriving at an empty buffer, since it is directed to transmit over the link. For the two packets arriving at an empty buffer third delay is equal to transmission delay of the first packet arrived and the n^{th} packet will have (N-1) times the transmission delay.

$$d_q = \sum_{n=1}^{N}(n-1)d_t$$
$$d_q = d_t\left(\frac{N(N-1)}{2}\right) \quad (1)$$

Average Queuing Delay

Most often average queuing delay is measured to derive a relation between *queuing delay and number of data packets.* It is defined as the sum of delays of each packet by the total number of packets.

$$d_{qa} = \left(\frac{d_q}{N}\right)$$

$$d_{qa} = d_t\left(\frac{N-1}{2}\right) \quad (2)$$

Transmission Delay

The amount of time consumed to pop out all of the packets bits onto the link constitutes *transmission delay* . This includes the addition of current router information and time for sending the acknowledgement signal to the parent router on successful transmission of message.

$$d_t = \frac{p}{r} \quad (3)$$

Propagation Delay

The time consumed by the packets to travel (via wireless links in air) from downstream router to the upstream router is called as propagation delay. It is value is usually in milliseconds. However it solely depends on the distance and mobility of the two nodes.

$$d_g = \left(\frac{D}{c}\right) \quad (4)$$

Table-1

Symbol	Definitions
D	*Total geometric distance of the route*
n_r	*No. of intermediate nodes*
r	*Data rate*
d_e	*End-to-end delay*
d_n	*Total nodal delay*
d_{nn}	*Nodal delay at* n^{th} *node*
d_p	*Processing delay*
d_q	*Queuing delay*
d_{qa}	*Average queuing delay*
d_t	*Transmission delay*
d_g	*Propagation delay*
c	*Link speed*
p	*Packet size*
N	*No. packets inside a buffer*
B	*Max.available bandwidth*

Delay

Thus ,for a route with R nodes in its way, end -to-end delay or *delay* is given as:

$$d_e = \sum_{n=1}^{R} d_{nn}$$

Hence by the knowledge of total nodal delay and no. of routers of the path, end-to-end delay can be calculated assuming noise, fading to be minimum.

B. Mathematical Modelling of Delay

A route will have a number of intermediate nodes and Each node constitutes to delay. For instance, if a route has R routers then its end-to-end delay derived from the equations (1) (2) (3) (4) is given as:

$$d_e = n_r(d_n)$$

$$= n_r(dp + dq + dt + dg)$$

$$f(d) = n_r\left(dp + \frac{p}{2r}(N+1)\right) + \frac{D}{c} \qquad (5)$$

Where N=max. Available bandwidth/packetize

The above function f(d) is called *delay function*. It is defined as a function which maps the real values of route parameters like *no. of intermediate nodes, processing delay (secs), max. Available bandwidth (bytes), geometric distance (km), data rate(Mbps), packet size(bytes), link speed(kmps),* to a *real valued end-to-end delay (sec)*.

C. Algorith for minimum delay routing protocol(MDRP)

Step1: *Let each route have route tabel with processing delay, max. available bandwidth, geometric distance, data rate, packet size, no. of intermediate nodes.*

Step2: *Arrange the routes in ascending order of no. of hopcounts and rank them.If two routes have same hopcount take data rate for sorting.*

Step3: *Now for each route apply the delay function.*

Step4: *Rank the route as per the increasing order of delay function values.In case of same values consider hopcount for sorting.*

Step5: *Assign the route rank-wise.In case of route failure,assign the route having next best rank.*

Step6: Repeat step-2 to step-5 until data is transmitted.

III. DEMOSTRATION MODELS

We present two models representing the critical topologies of Heterogeneous MANETs, among the numerous possible topologies. The first models deals with least delay path estimation and the second model describes the basics for application of the proposed to Multimedia transmission through parallel links.

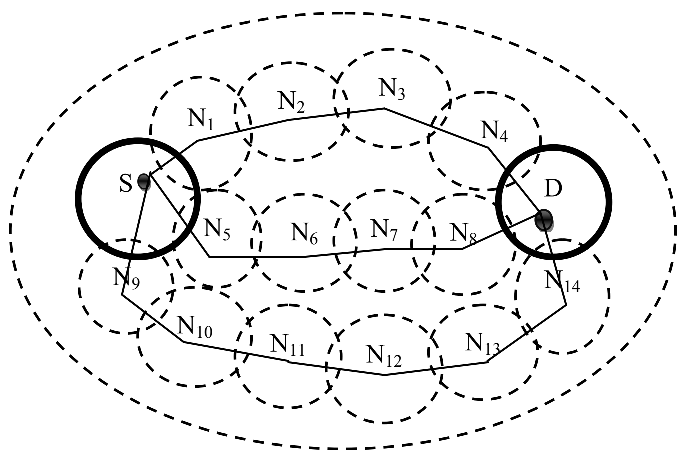
A. Model 1(Minimum delay rotuing)

consider a specific MANET topology,where there are three different possible configurations of routes from source to destination,there route parameters are tabulated as follows.

Table 2

Route no.	No. of Hops	Distance	Data rate
1	4	10	35
2	5	100	45
3	6	150	54

Figure-1



Solution: For such a network a greedy forwarding protocol will choose shortest path for transmission without taking care of data rate of intermediate routers. Another efficient approach is made by the author [9], where a path with maximum data rate is selected for transmission.

On solving delay function values for these parameters, to find the path with least delay.

We get delay values as,
D =5.099 ms for the first path,(DSDV path)
=3.9 ms for the second path,(MDR path)
=6.5 ms for the third path,(BRAWN path)

Thus the two approaches given by the authors [8,9] may not guarantee minimum delay transmission of the message. But the path with optimum data rate (34<45Mbps<54) and optimum distance (10<100km<150) may also be *efficient*. Whatever may the route parameters its delay can be predicted with the application of delay formulation subjected to noise and fading free transmission.

B. Model 2(Enhanced Multimedia Transmission)

Consider the MANET of fig.1 to be of PDAs with different IEEE 802.11 a/b/e standards, where source and destination wishes to have *multimedia transmission*, the parameters of the available parallel links are appended as with A/V QoS given in table below.

Solution: The utilization of a network will be optimum, if congestion is minimized, delay is least and synchronization is achieved between the audio and video frames arriving in parallel at the destination. This will provide jitter free transmission. We attempt to allocate the different paths to audio packets and video packets, such that both will have equal time of transmission for synchronization. To achieve this we equate the delay function values of the two paths. In the present model, we assumed the audio frame size equal to 1500 bytes now the task is to find the approximate size of video frames that is fits for synchronization, notice that video frame sizes can be achieved by the use of various *compression techniques*[12] using various frame formats.

There are three possible routes from source to destination. Any two links can be used for A/V transmission.

Hence there will be three possible combinations. Let's consider the two combinations Audio1 on route 1, video1 on route 2 and Audio2 on route 3, Video2 on route2.

Now, the task is to find the Video frame size for given Audio frame size obtained from particular compression technique or vice versa.

The primary task is to avoid delay jitters and to minimize/eliminate timestamps. This can be achieved by *equating the delay functions* of the routes and solving for required frame size.

For first combination, we assumed audio frame size to be 800bytes, and then the video frame size should be upto 4219bytes to minimize timestamps. Under second combination, we assumed audio size to be 3000bytes,we get the cut-off video frame value to be 6024 bytes.

Table-3

Route no.	Audio frame (bytes)	Video frame (bytes)	Multimedia Transmission Link pairs.
1	800	xxx	Audio1
2	xxx	4219*	Video1
2	xxx	6024*	Audio2
3	3000	xxx	Video2

IV. CONCLUSIONS

In this paper, we mathematically formulated end to end delay for MANETs in terms of network parameters like data rate, distance, packet size, which can be significantly applied to QoS demands including Multimedia transmission over Ad-hoc networks. Moreover, the networks are considered to be wide spread to demonstrate that the propagation delays as well as the data rate are vital parameters for delay minimization. By the use of Optimum path having optimum number of nodes, energy consumption can be greatly reduced, as nodes are battery operated. Mobility of the nodes is also considered to compare with end-to-end delay for the accomplishment of successful transmission. Our model maintains multiple routes with ranking and routing decision based on the throughput, which can help during failure of any route.

Apart from this, we presented enhanced Multimedia transmission routing, which will suit best for QoS maintenance. Such approach increases the utility of other routes and hence the congestion over the optimum path is greatly reduced, since we directed the audio frames, which are smaller in size to the other paths. Such that both received at the destination in synchronization with parallel transmission in heterogeneous MANTEs, the proposed model is also helpful in determining the frame sizes for an effective route utilization and efficient resource allocation.

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