Quality of Service in Mobile Adhoc Networks using Two Bandwidth Estimation Method in Optimized Link State Routing protocol

M.Pushpavalli[1] ***Dr.A.M.Natarajan***[2]

[1]Assistant Professor (Senior Grade) /ECE Bannari Amman Institute of Technology, Sathyamangalam
[2]Chief Executive and Professor Bannari Amman Institute of Technology, Sathyamangalam.

Abstract:
An adhoc network is a collection of mobile nodes connected by a wireless link, where each node acts as a router. In order to facilitate the communication within the network, a routing protocol is needed. Due to bandwidth constraint and dynamic topology of the mobile adhoc Networks supporting Quality of Service (QoS) is challenging ta sk. To have proper traffic management in mobile adhoc Networks, we should be able to effectively determine the available resources at our disposal. Therefore a Quality of service framework for mobile adhoc Networks should be equipped with reliable bandwidth estimation method. In this paper we have propose a two bandwidth estimation technique to calculate the available bandwidth. It uses twotechniques such as busy method and hello method. OLSR protocol is taken and the performance is analyzed based upon delay and throughput. The standard protocol OLSR is compared with modified OLSR protocol and it is found that the modified protocol due to two bandwidth estimation technique gives better performance than standard protocol.

Keywords
Mobile adhoc networks, Two Bandwidth method,Quality of Service, OLSR, delay and throughput

1. Introduction

A mobile adhoc network is a collection of nodes that do not need to rely on a predefined infrastructure to keep the network connected. Adhoc networks can be formed, merged together or partitioned into the separated networks on the fly, without necessarily relying on a fixed infrastructure to manage the operation. Nodes of adhoc network s are often mobile, which also implicates that they apply wireless communication to maintain the connect ivity, in which case the networks are called as mobile adhoc networks (MANET). In adhoc networks all nodes are mobile and can be connected dynamically in an arbitrary manner. All nodes of these networks behave as routers and take part in discovery and maintenance of routes to other nodes in the network. Therefore , routing protocols in adhoc networks must be adaptive to face frequent topology changes because of node mobility. Some examples of the possible uses of ad hoc networking include students using laptop computers to participate in an interactive lecture, business associates sharing information during a meeting, soldiers relaying information for situational awareness on the battlefield and emergency disaster relief personnel coordinating efforts after a hurricane or earthquake.

2. Literature Survey

It is important to realize that the QoS routing is very much dependent on the accuracy of the information such as resource availability at network nodes and quality of the links. QoS routing relies on the QoS-related state information and uses it to find paths that can satisfy certain QoS requirements. Admission Control scheme is an important component of a network for providing QoS assurances.In our paper IEEE 802.11 MAC layer is taken and the same MAC layer bandwidth is considered for the transmission. With this available bandwidth the estimations and proposed bandwidth estimations are done. A QoS-aware routing protocol is proposed in [1].The authors introduce the band-width estimation by disseminating bandwidth information through Hello messages. The authors compare two different methods of estimating bandwidth. The Hello bandwidth estimation method performs better than the Listen bandwidth estimation method when releasing bandwidth is immediately important. The Hello and Listen methods work equally well in static topologies by using large weight factors to reduce the congestion and minimize the chance of lost Hello messages incorrectly signaling a broken route. In a mobile topology, Hello performs better in terms of end-to-end throughput, and Listen performs better in terms of the packet delivery ratio.
Contention-based access of IEEE 802.11 standard makes it unable to fit the requirements of multimedia applications over multihop networks. The standard suffers serious throughput degradation and unfairness due to the hidden terminal and the exposed terminal problems, and the binary exponential backoff [2] The IEEE 802.11e standard MAC enhancements enables some QoS

Manuscript received January 5, 2012
Manuscript revised January 20, 2012

guarantees through MAC level service differentiation. However, its throughput is expected to degrade at high traffic load.
To assist QoS routing, the topology information can be maintained at the nodes of ad hoc wireless networks. The topology information needs to be refreshed frequently by sending link state update messages, which consume precious network resources such as bandwidth and battery power. Otherwise, the dynamically varying network topology may cause the topology information to become imprecise. This trade-off affects the performance of the QoS routing protocol. As path breaks occur frequently in ad hoc wireless networks, compared to wired networks where a link goes down very rarely, the path satisfying the QoS requirements needs to be recomputed every time the current path gets broken. The QoS routing protocol should respond quickly in case of path breaks and recompute the broken path or bypass the broken link without degrading the level of QoS. This is a complex and difficult issue because of the dynamic nature of the network topology and generally imprecise network state information [3].
When we estimate the available bandwidth, we must take into account the activities of the neighbors of nodes since the wireless medium of a node is shared among neighboring nodes. The available bandwidth estimated is based on the channel status of the radio and compute the idle periods of the shared wireless media. By using this method the activities of neighbors of node is considered; where any send or receive from other nodes will affect the channel status. In this method, for estimating the available bandwidth, each node can listen to the channel to determine the channel status and computes the idle duration for a period of time t; in our approach t = 1 s. The Idle Time (Ti) is composed of several idle periods during an observation interval t; the node adds all the idle periods to compute the total idle time. The idle ratio (R) for each period of time t is calculated as:

$$R = Ti / t \qquad (1)$$

The available bandwidth BWavail:

$$BWavail = R * BW \qquad (2)$$

where BW is the raw channel bandwidth [4] (2Mbps for standard IEEE 802.11 radio) After the node finishes computing the available bandwidth during a period of time t at the MAC layer [5], it sends the information of the available bandwidth to the Network layer and starts computing available bandwidth during the next period of time t. During this time, QoS requirements of other ongoing flows that use the same or nearby FNs are respected and protected [6]. This is better than using extra overhead to free the allocated bandwidths. This derived version of bandwidth estimation is E-QMR.

3. QoS in Adhoc networks

QoS provision will lead to an increase in computational and communication cost. In other words, it requires more time to setup a connection and maintains more state information per connection. The improvement in network utilization counterbalances the increase in state information and the associated complexity and various issues are needed to be faced while providing QoS for MANETS. The major

3.1 Available Bandwidth Estimation in Mobile Adhoc Networks

To measure available bandwidth between two nodes, it is nnecessary to consider the bandwidth consumed by its neighbor nodes. Capacity of the node to transmit data can be traced using channel utilization ratio. It is also important to consider the collision of frames which has an impact on available bandwidth measurement and backoff mechanism to reduce collision [10]. Let UB be the utilized bandwidth of a node which is calculated as follows.
UB = Number of packets sent x size of packets x 8 / time period (3)
Available Bandwidth is calculated by subtracting utilized bandwidth by channel capacity. Upper limit for available bandwidth AB is (Total idle time(s)/observation period) Capacity of the medium. Collision probability Pm is estimated based on hello packets and packets of transmitted bits. ie

$$Pm=f(m).Ph \qquad (4)$$

Where, f(m) is lagrange interpolated polynomial function and

Ph = (Expected - Recorded no. of Hello pkts) / Expected no. of Hello packets (5)
But still there is some bandwidth loss due to the additional overhead introduced by backoff mechanism [11]. Common method or way to measure the network utilization is to subtract it from available channel capacity. Several techniques are used to measure the network utilization such as MAC layer congestion window,queue length,number of collisions, delay and channel busy time. In our proposed method a new QoS rouitng algorithm for MANETs based upon bandwidth estimation and link breakage is used and OLSR protocol is to analyze the QoS metrics.

3.2 Methodology to calculate MAC bandwidth

Many types of bandwidth measurement algorithms have been proposed. In a real time scenario, nodes in adhoc network shares the radio channel based on contention i.e Neighboring nodes will share the same channel periodically either based on a time division principal or orthogonal frequency sharing principal. Hence we have considered a MAC bandwidth measurement. Before going to the proposed method let us see the draw backs and advantages of several methods that are used to estimate the available bandwidth. The delay method which is an active measurement technique, injects probe packets into the network bandwidth that solicit responses with a measurement from the packets it received. This increases overhead on the network and therefore consumes more bandwidth.[12]
The Channel busy time-metric is a direct passive measure of the channel utilization. In wireless networks, carrier sensing enables nodes to detect three states; transmitting, receiving and busy. Using these metrics, more transmissions result in a busier channel. We define the busy time to be the total time within an interval that a node is transmitting packets, receiving packets or sensing packet transmissions.The busy time method has one disadvantage that it the host cannot realize the bandwidth when there is link breakage. Because it does not know how much bandwidth that the broken link consumes.[4].
In hello method, the hello messages are used to update the neighborhood caches. These message keeps the address of the host who initiates it. If this hello message is modified it can be piggy-backed with information containing the bandwidth consumed by each host and the bandwidth consumed by its neighbors. Each host can approximate its residual bandwidth information based on information from hosts within two-hops (the interference range). The hello message is modified so that it contains two fields. The first field includes host address, consumed bandwidth, timestamp, and the second field includes neighbors addresses, consumed bandwidth, timestamp. The main disadvantage in hello method is hidden node problem. We therefore propose a new method so that a route can be available when a royte is broken and another route can be chosen when all routes are available.

3.3 Proposed Method

Thus a new bandwidth estimation is made based up all routes are available and a route with broken link. The name of the proposed method is called as two bandwidth method (TBM) which uses both hello method and busy method to calculate available bandwidth. In TBM when there is a route hello message is used and when there is no link or if the route is broken busy method is used.

In busy method , MAC layer detects that the channel is free when the used average Network Allocation Vector (NAV) is less than the current time, when the receive state is idle and send state is idle. It also detects that the channel is busy whenever the NAV sets a new value, receive state changes from idle to any other state and the send state changes from idle to any other state. The available bandwidth is calculated as:

$$AvB = \frac{(1 - NUt)Bm}{wgt} \qquad (6)$$

where, AvB - Available Bandwidth
NUt - Network Utilization
Bm - Maximum Bandwidth
Wgt - Weight factor of MAC layer

In hello method, each host determines the consumed bandwidth by monitoring the traffic it feeds into the network. Once a host knows the bandwidth consumed by 1st hop and 2nd hop means it can calculate the bandwidth consumed by all the nodes in the interference range. If there is a broke in the link means hello method of estimation is done otherwise busy method is taken into account to calculate the bandwidth. If there is a link breakage means hello method of estimation is done otherwise busy method is taken into account to calculate the bandwidth.
OLSR protocol uses hello messages to update the neighborhood informations. These messages keep the address of the host which initiates the message. If this "hello" message is modified it can be piggy-backed with information containing the bandwidth consumed by each host and the bandwidth consumed by its neighbors. Each host can approximate its residual bandwidth information based on information from hosts within two-hops (the interference
range). The "hello" message is modified so that it contains two fields. The first field includes host address, consumed bandwidth, timestamp, and the second field includes neighbors' addresses, consumed bandwidth, timestamp.
The bandwidth consumed by all the node is calculated as ,

$$AvB = \frac{\frac{Bm - \Sigma ConB}{n}}{wgt} \qquad (7)$$

Where, AvB - Available Bandwidth
Bm - Maximum Bandwidth
ConB - Consumed Bandwidth
Wgt - Weight factor of MAC layer
n - All nodes in same neighborhood

4. Optimized Link State Routing Protocol(OLSR)

OLSR is a proactive protocol where the routing tables are available in each and every node in the topology. The OLSR protocol is an optimization of a link state routing protocol for mobile adhoc network. First, it reduce the size of the control packets, instead of all links, it declares only a subset of links with its neighbors that are called as its multipoint relay selectors. Secondly, in minimizes the flooding of its control traffic by using only the selected nodes, called multipoint relays of the node retransmit the packets technique significantly reduces the number of transmissions.(flooding (or) broadcast procedure)

The key concept used in the protocol is that of multipoint relays (MPRs). The MPR set is selected such that it covers all nodes that are two hops away. The nodes selected as a MPR by some of the neighbor nodes, announce periodically in their control messages their condition of MPR to their neighborhood . Thereby, a node announces to the network, that it has reach ability to the nodes, which have selected it as MPR. In route calculation, the MPRs are used to form the route from a given node to any destination in the network . The protocol uses the MPRs to facilitate the efficient flooding of control messages in the network. A node selects its MPR among its on-hop neighbors with symmetric link. Therefore, selecting the route through MPRs automatically avoids the problems associated with data packet transfer over unidirectional links. Each node maintains information about the neighbors that have selected it as MPR. A node obtains such information from periodic control messages received from the neighbors.

The fig.4 is an example of MPR here m1, m2, m3 nodes are selected as MPRs in 1-hop neighbors. MPR is selected such that it covers 2-hop distance thus hop-by-hop routing technique is followed here. A node 's knowledge about its neighbors and two-hop neighbors is obtained from HELLO messages which are the message each node periodically generates to declare the nodes that it hears. The node N, which is selected as a multipoint relay by its neighbors periodically generates TC (Topology Control) messages, announcing the information about who has selected it as an MPR. Apart from generating TCs periodically, an MPR node can also originate a TC message as soon as it detects a topology change in the network. A TC message is received and processed by all the neighbors of N, but only the neighbors who are in N's MPR set retransmit it.[14]

Using this mechanism, all nodes are informed of a subset of all links - links between the MPR and MPR selectors in the network . So, contrary to the classic link state algorithm, instead of all links, only small subsets of links are declared. For route calculation , each node calculates its routing table using a "shortest hop path algorithm" based on the partial network topology it learned. MPR selection is the key point in OLSR. The smaller the MPR set is, the less overhead the protocol introduces. The proposed heuristic in for MPR selection is to iteratively select a I-hop neighbor that reaches the maximum number of uncovered 2-hop neighbors as an MPR. If there is a tie, the one with higher degree (more neighbors) is chosen.

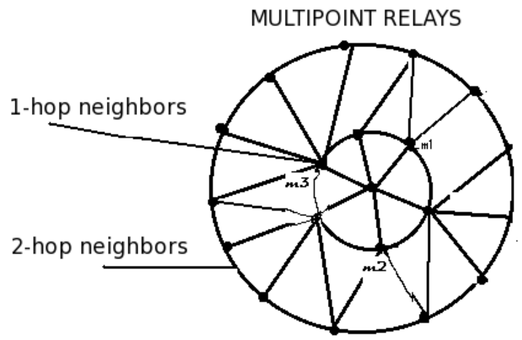

Fig. 4 Multipoint Relay

4.1 . Hop-By-Hop Routing Technique

OLSR protocol performs hop by hop routing (i.e.) each node uses most recent information to route a packet. In hop-by-hop routing, the route to a destination is distributed in the "next hop" of the nodes along the route. When a node receives a packet to a destination it forwards the packet to the next hop corresponding to the destination. If c receives from a first it will retransmit. If c receives from b first it won 't re transmit, no node will missed, any neighbor d of c is a 2-hop neighbour of b and some MPR of b will covered.

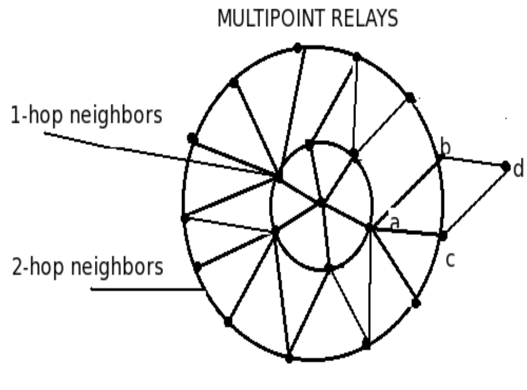

Fig.4.1 Hop by Hop Routing

5. QOS IN OLSR PROTOCOL

5.1 Limitations of OLSR in QoS routing

OLSR is a routing protocol for best-effort traffic, with emphasis on how to reduce the overhead, and at the same time, provide a minimum hop route. So in its MPR selection, the node selects the neighbor that covers the most unsearched 2-hop neighbors as MPR. This strategy limits the number of MPRs in the network, ensures that the overhead is as low as possible. However, in QoS routing, by such an MPR selection mechanism, the good quality links may be hidden to other nodes in the network.

5.2 Changing of MPR selection criteria

The decision of how each node selects its MPRs is essential to determining the optimal bandwidth route in the network. In the MPR selection, a good bandwidth link should not be omitted. In other words, as many nodes as possible that have high bandwidth links connecting to the MPR selector must be included into the MPR sets. Based on this idea, MPR selection algorithm is presented. The algorithm selects the MPRs in a way such that all the 2-hop neighbors have the optimal bandwidth path through the MPRs to the current node. Here, optimal bandwidth path means the bottleneck bandwidth path is the largest among all the possible paths.

1. Start with an empty MPR set
2. Select as MPRs nodes in neighbor N which provide the only path to some nodes in 2-hop neighbors N2
3. While there exist nodes in N2 which are not covered
   3.1. Select as MPR a node so that the current node has the optimal route through the MPR to a 2-hop node.
   3.2. Mark the 2-hop node as covered

Look again at node B in Figure 2.2 as an example. In order to cover D, neighbors A, C, or F need to be chosen as an MPR. Bandwidths available from B to D for three different routes are:

B -110- A - 5 - D bottleneck bandwidth is 5
B - 50 - C - 3 - D bottleneck bandwidth is 3
B -100- F -10 - D bottleneck bandwidth is 10

The algorithm chooses the route with the largest bottleneck (in 2 hops). In this case the chosen MPR is F. In the same way, C is chosen as MPR by B to cover E.

5.3 Delay and Throughput Measurements

The delay and throughput metrics are taking into account as QoS constraints for the modified OLSR (MOLSR) protocol. Such metrics are included on each routing table entry corresponding to each destination. Bandwidth estimation is done based upon the proposed method .

5.4 Delay Metric

With the modified OLSR (MOLSR) protocol, a route is immediately available when needed satisfying the QoS requirements. So, before sending data traffic we must inform each node about the delay information between any node and its MPRs. Thus delay is calculated by using control traffic messages. Each node in the adhoc network periodically broadcasts locally its HELLO messages. These control messages are transmitted in broadcast mode without acknowledgments in response. Round trip time is measured. [15],[16]. In synchronized networks, measured delay's computing is very simple. Each node includes in the HELLO massage, during the neighbor discovery performed by the OLSR, the creation time of this message, when a neighbor node receives this message, it calculates the difference between such a time and the current time, which represents the measured delay. IEEE 802.11b as the medium access control represents the measured delay as,

$$\text{Delay} = Mtq + (Tt, + CAt + to) \times NT + Br \qquad (8)$$

Where, Mtq=Mac queuing time
Tts=Transmission time of s bits
CAt=Collision Avoidance phase time
to=Control overhead time
NT=Number of necessary transmissions
Br=Back off time .

5.5 Throughput Metric

The throughput is calculated between a node and its neighbors having direct and symmetric link. Here we consider data packets and signaling traffic that uses the available bandwidth. (e.g.)HELLO messages and Traffic control messages in the OLSR protocol.[15]The source - neighbor pair through put is measured for a window of packets using existing traffic each successful packet transmission contributes its bits to the numerator of the throughput measurement and the time from when it was ready to transmission at the head of the link queues to the acknowledgment receipt. IEEE802.11 b as medium access control, this interval is packet size dependent as shown in the below equation.

$$\text{Through put (packet)} = \frac{S}{\text{Delay}} \qquad (9)$$

6. Performance Evaluation

Simulation is carried out by using NS-2.29, OLSR and modified OLSR (MOLSR) are analyzed with respect to proposed bandwidth estimation by taking different configurations and scenarios.

Area : 500mx500m,Number of nodes : 50
MAC : IEEE 802.11b,Pause time :7s,10s
Mobility : 10m/s ,20m/s,
Parameters Analysed : Delay, Throughput,Packet Delivery Ratio

Depending upon the network conditions the two bandwidth method is used. Busy method is used to calculate the bandwidth, if the network is stable. Hello method is used to calculate the bandwidth in case of break up in the network. The change of the network state from stability to instability will be represented as the change of the generated random numbers 0 or 1.

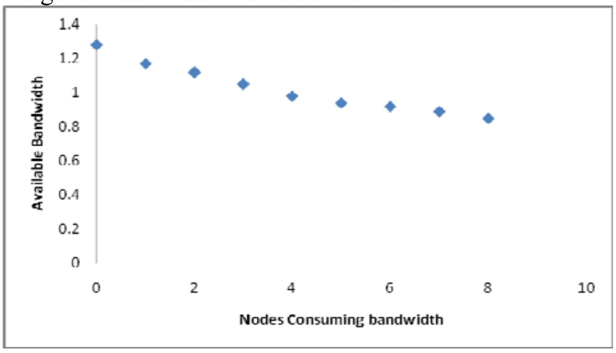

Fig.6.1 Variation of nodes consuming available bandwidth

In our simulations it is assumed that nodes are sending the same type of traffic so the available bandwidth is inversely proportional to number of bandwidth consuming nodes.Fig.6.1 shows that the available bandwidth decreases as the number of bandwidth consuming nodes increases.

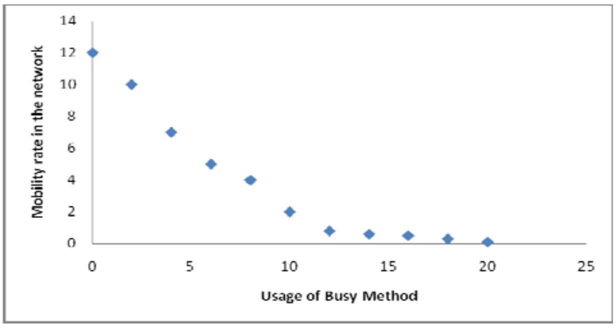

Fig 6.2 Usage of busy method

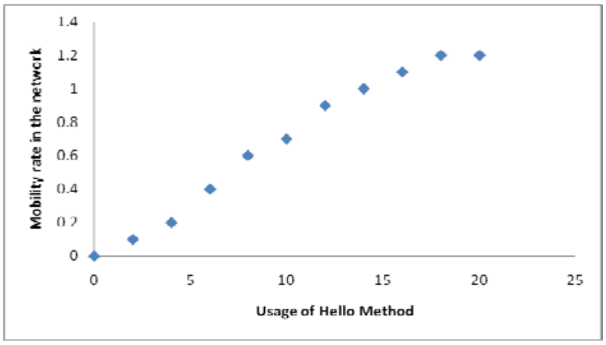

Fig 6.3 Usage of hello method

From the simulations we have found out that as the mobility increases, the use of the busy method decreases fig.6.2 and the use of "hello" message increases.fig. 6.3 Mobility is measured by the rate of change of number of nodes per second. Thus there will be a great risk for the network to break when there is a lot of mobility .

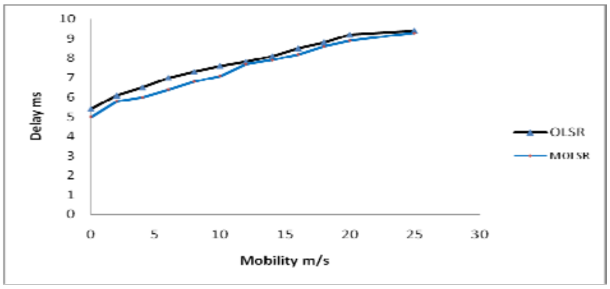

Fig 6.4 Mobility vs Delay

Fig.6.4 shows the delay for different mobility speeds . 50 nodes are considered for the adhoc network. The delay increases when the mobility speed increases. The reason is that high mobility results in frequent link breaks and rerouting. The proposed MOLSR protocol reduces the delay compared to standard OLSR.

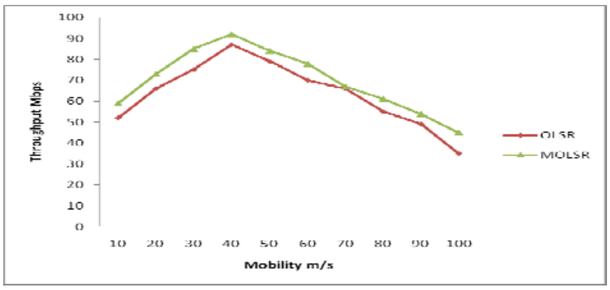

Fig 6.5 Mobility vs throughput

Fig.6.5 shows the comparison of mobility (m/s) versus throughput (Mbps) for standard OLSR and proposed MOLSR protocol for various mobility . In both the cases there is a decrease in throughput , this is due to the congestion in the traffic. In standard OLSR the throughput decreases after 50 m/s but in the proposed protocol MOLSR we have an improvement in the throughput up to 80m/s.

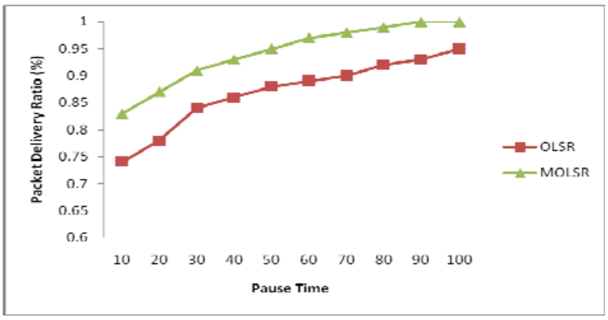

Fig 6.6 Pause Time vs Packet Delivery Ratio

Fig. 4.1 shows the packet delivery ratio varies with pause times and the mobility is taken as 10m/s. Here the number of nodes is taken as 50.As pause time increases packet delivery ratio also increases .It is easy to understand that with the lower pause time, the established links between the nodes have a lower probability to break, which results in a higher delivery ratio. The delivery ratio is increased around 15 % than the standard OLSR.

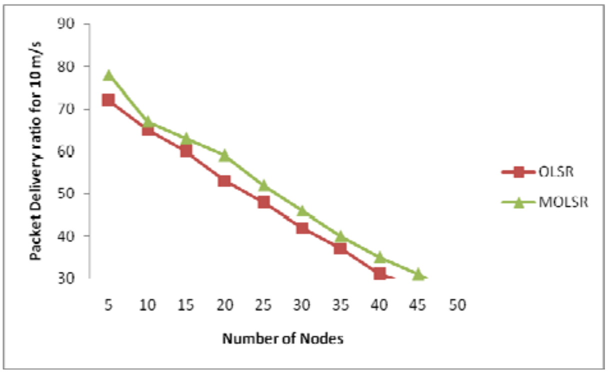

Fig 6.7 Nodes vs Packet Delivery Ratio

Fig 6.7 As the number of nodes increases packet delivery ratio decreases in both the cases due to more number of links but compared to standard OLSR, in our protocol the packet delivery ratio is improved about 4%.
our protocol gives better performance from low mobility (10m/s) to high (90m/s) except in the small middle range (40 to 50 m/s).From the graph we observe that our protocol has better throughput and packet delivery ratio.

7. Conclusion

The performance of Two Bandwidth Estimation Method (TBM) is better than the conventional methods. Since it can offer better estimates with respect to link breakages. Adhoc networks provide a method for communicating between mobile devices without requiring an infrastructure.Direct communication is possible between nodes that are located within range and intermediate nodes are used to route messages to destinations beyond a single hop. Bandwidth utilization is a big problem in real time networks. In this paper we have proposed protocol with two bandwidth estimation method which provides QoS guarantees in terms of better throughput and less delay. Simulation results demonstrate that our protocol is effective and efficient in the QoS provisioning. Our future work is the performance evaluation for different scenarios and some heuristic algorithms can also be used to select the MPR nodes and admission control method and a resource reservation method can be used to bandwidth estimation.

References:

[1] L. Chen, W. B. Heinzelman. “QoS-Aware Routing Based on Bandwidth Estimation for Mobile AdHoc Networks,” IEEE Journal on Selected Areas in Communications, Vol. 23, No. 3, 561-572, 2005.

[2] H. Zhu, G. cao, A. Yener and A. D. Mathias, EDCF-DM: A Novel Enhanced Distributed coordination Function for Wireless Ad Hoc Networks, IEEE International Conference on Communications (ICC),Paris, France, June 2004.

[3] S. Chakrabarthi, and A. Mishra, “QoS issues in ad hoc wireless networks”, IEEE Communications Magazine, Vol. 39, no. 2, pp. 142 - 148, Februray 2001.

[4] H. Wu and X. Jia, "QoS multicast routing by using multiple paths/trees in wireless ad hoc networks," Elsevier,Ad Hoc Networks , vol. 5, p. 600 - 612, 2007.

[5] Y.-S. Chen, T.-S. Chen, and C.-J. Huang, "SOM: spiral-fat-tree-based on-demand multicast protocol in a wireless ad-hoc network ," Computer Communications, vol. 25, no. 17, pp. 1684-1695, 2002.

[6] C. Lin and J. Liu, "QoS Routing in Ad Hoc Wireless Networks," IEEE on Selected Areas in Comm. , vol. 17,no. 8, pp. 1426-1428, Aug 1999.

[7] S.Saunders,Antennas and Propagation for Wireless Communication System Concept and design, New York, USA: John Wiley and Sons, 1999.

[8] Y.Luo, J.Wang and J.Chen et al., “Algorithm based on mobility prediction and probability for energy efficient multicasting in ad-hoc networks” Computer research and development vol.43(2), pp.231-237,2006.

[9] Y.Yang and R.Kravets ,"Contention-aware admission control for ad hoc networks", IEEE Trans.Mobile Comput., vol.4, 363-377, 2005.
[10] Cheikh Sarr, Claude Chaudet, Guillaume Chelius, and Isabelle Guerin Lassous Bandwidth Estimation for IEEE 802.11-Based Ad Hoc Networks, IEEE Transactions on Mobile Computing, VOL. 7, NO. 10, October, 2008.
[11] Cheikh Sarr, Claude Chaudet, Guillaume Chelius, and Isabelle Guerin Lassous, Bandwidth Estimation for IEEE 802.11-Based Ad Hoc Networks, IEEE Transactions on Mobile Computing, VOL. 7, NO. 10, October, 2008
[12] D .Chackeres, E. M. Belding Royer,PAC: Perceptive Admission Control for Mobile Wireless networks. Proc. of 1st International Conference on Quality of Service in Heterogeneous Wired/Wireless Networks (Qshine), Dallas, Texas, 2004. [pp 18-26].
[13] M Liu1, Z. Li1, J. Shi1, E. Dutkiewicz, R. Raad ,"An On-Demand QoS Routing Protocol for Mobile Ad Hoc Networks" Springer-Verlag Berlin Heidelberg , pp. 207-218, 2004.
[14] Clausen.T and PJacquet, "Optimized Link State Routing Protocol," In *IETF Internet Draft,* draft ietf - manet - olsr- 1l.txt, July 2003.
[15] Kazantzidis and Gerla.M, "End- to- end versus Explicit Feedback Measurement in 802.11 Networks" In *Seventh IEEE Symposium on Computers and Communications, 2002.*
[16] Kuipers.F, Van.P Mieghem, Korkma.T and Krunz.M, "An overview of Constraint - Based Path Selection Algorithms for QoS Routing" *IEEE Communications magazine,*Vo1.40, No.12, December 2002.

Dr.A.M.Natarajan is the Chief Executive &Professor at Bannari Amman Institute of Technology, Sathyamangalam, Coimbatore.. He has 40 years of teaching experience. He received the "Best Engineering college principal award in India for the Year 2000" from Indian Society for Technical Education, New Delhi. He has published more than 80 papers in International and National journals and conference proceedings. He has published 10 books. His areas of research include systems engineering and computer networks.

M.Pushpavalli, received her B.E. degree in Electronics and Communication Engineering from Bharadhiyar University. She received M.E. degree in Applied Electronics from Anna University Chennai with distinction and with university fourth rank. She has 8 years of teaching experience. She is currently pursuing doctoral research in wireless networks. At present she is working as Assistant professor(senior grade) in Electronics and Communication Engineering Department at Bannari Amman Institute of Technology, Sathyamangalam.