Reliable Metrics for Wireless Mesh Network

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ABSTRACT: ***Wireless mesh network is progressing technology in the field of wireless networking. WMN is wide spreading network due to its advantages such as low deployment cost, easy maintenance, scalability, reliable service coverage and high performance. It is compatible and interoperable with existing wireless networks. Wireless mesh network is based on IEEE 802.11 standard according to which the packet delivered must be acknowledged. The quality of service (QoS) and throughput of the network in WMNs can be enhanced by using layer routing metrics. The routing metrics developed for ad hoc network can be applied for wireless mesh network as it shares some features of ad hoc network. Existing routing protocols must include some performance metric such as the power requirements and mobility. This article represents qualitative comparison of existing routing metrics Expected transmission count [ETX], Expected Transmission time [ETT], load aware expected transmission time [LAETT]. Comparative analysis of Metrics is evaluated through simulation by considering performance metrics like packet delivery ratio, average throughput, bandwidth utilization.***

Keywords - layer Metric, wireless mesh network.

I. INTRODUCTION

Wireless Mesh Network (WMN) is an emerging technology making progress in the field of wireless networking. It is expected to be widespread due to low deployment cost, easy network maintenance, robustness, scalability, reliable service coverage and high performance. WMN has self-configurable ability and self-healing ability.WMN consists of wireless nodes organized in an arbitrary mesh topology. The three types of nodes in WMN are mesh clients, mesh routers and gateways. Mesh clients are the end user devices such as laptops, smart phones and so on. Mesh routers are the devices that forward traffic to and from the gateways with the help of routing tables. Gateways are the routers with direct access to the wired infrastructure or Internet. The network topology of a typical wireless mesh network is as shown in Figure 1.

Wireless mesh networks are an innovative network technology that has emerged recent years. Wireless mesh network have many advantages like dynamic self organization, self configuration, high scalability, low cost and easy maintenance. Applications where wireless mesh technology is more suitable are: 1) Areas where extensive coverage requires, like offices campus networking stadiums.2) Areas where wired connections are difficult to structure such as highways, rural areas. 3) In emergencies like fire fighting, disaster recovery, military operations.

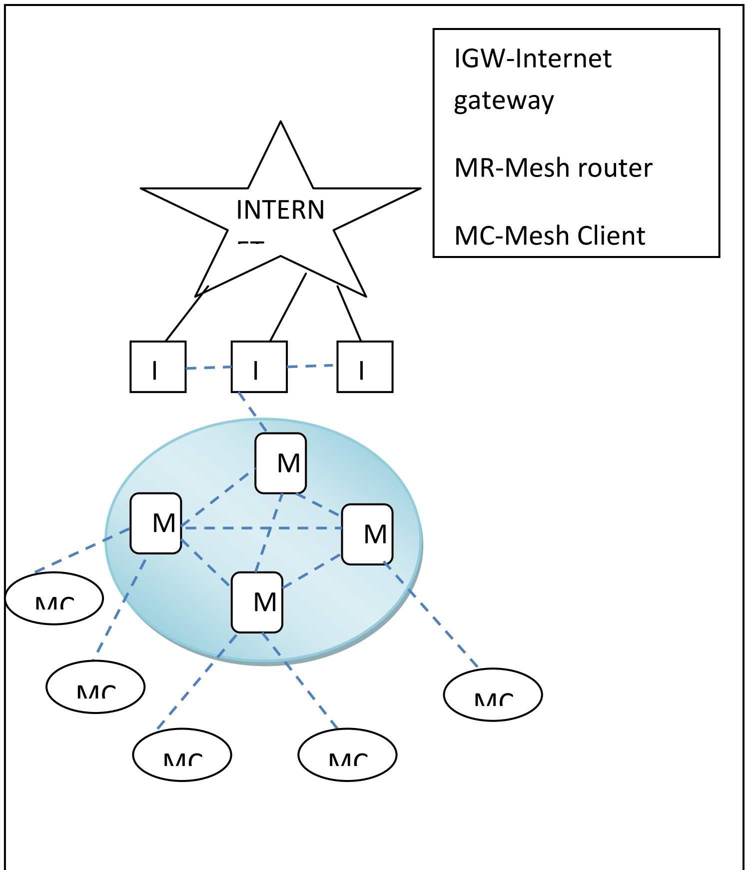


Figure1.Wireless mesh network.

Wireless mesh networks are classified in three types: 1) Client WMN provides peer-to-peer networking facility between the client nodes.Client nodes is normally single radio devices with optional routing capability depending on the end user requirements. Client WMNs are very simple to design but scalability and limited resource allocation are the critical issues which may cause throughput degradation in the network. 2) Hierarchical WMNs consist of a hierarchy in which mesh gateway routers are at the top with bridging functionality for backhaul internet connectivity, mesh routers are in the middle with self configuring and self healing functionality to act as a network backbone and mesh clients are at the bottom to serve as an end user.3) Hybrid WMNs consist of both hierarchical and client architectures. Mesh routers are equipped with the bridging functionality in order to integrate with other networks like wired networks. [1]

Wireless mesh network and ad hoc network have some features in common, thus the routing protocols developed for ad hoc network can be applied for Wireless mesh network. But these routing protocols must include some performance metrics; since the power requirements and mobility features of wireless mesh networks are different from ad hoc networks [1] Routing is an important process for quality of service and efficient utilization of

bandwidth. To maximize the bandwidth utilization and to improve network capacity, channel assignment is used in multichannel wireless mesh network. Channel assignment minimizes the overall interference. The key components used to compose routing metrics are (1) Throughput, which can be calculated by the number of received packets in a particular time (finish time-start time). (2)Packet Loss Rate (PLR) is the ratio of, the number of packets broadcasted in a particular time to the number of packets reported. (3)Expected transmission count (ETX) is a measure of link quality. It considers the number of unicast packets need to be transmitted at the MAC layer to traverse the link successfully. [2]. EXT design does not mention that different communication links may have different transmission rates which is considered for (4) Expected Transmission time [ETT], (5) load aware expected transmission time [LAETT],Load aware expected transmission time (LAETT) has incorporated the load balancing and link quality component in ETT to remove the drawback of ETT

II. ROUTING METRICS

Routing metrics play a critical role in path selection and in route optimization in MCMR WMNs. Routing metrics are composed of set of parameters capture at different layers.

1. Expected transmission count (ETX): is defined as the number of expected transmission plus retransmissions required to successfully deliver a packet over a wireless link. If forward delivery ratio *dfwd* , i.e., probability that the packet successfully received at destination node and reverse delivery ratio *drvs* , i.e., probability that acknowledgment of the packet successfully received at source node, then ETX of the link is calculated as follows:

$ETX = 1 / dfwd.drvs$

ETX metric has significantly improved performance over minimum hop count routing metric ETX develop its design foundation on delivery ratios which truly effects the throughput as compared to minimum hop count metric. Furthermore, ETX take account of asymmetry of links in a duplex manner by considering the loss ratios.

2. Expected Transmission Time (ETT): IEEE 802.11 MAC layer protocols have multi rate transmission ability which has increased the throughput of the wireless networks significantly .EXT design does not mention that different communication links may have different transmission rates. ETX was developed only by considering the average channel conditions. To solve the problems of ETX, expected transmission time (ETT) was designed which has significantly enhanced the performance of ETX by measuring the transmission rate of each individual link. ETT is defined as follows:

$ETT = \sum ETXi \, (S/Bi)$

Where *S* is the packet size, *pj* is the rate of packet loss and *Bj* is the transmission rate of link *j*. The main idea behind the design of ETT metric is the use of multi radios in multi hop wireless networks to enhance the network performance. ETT is the combination of packet loss rate and transmission rate of each individual link. ETT is an enhanced version of ETX with improved performance but still inherit the drawbacks of ETX being unaware of traffic load, intra-flow interference, inter-flow interference and channel diversity in WMNs. The design of ETT does not capture the losses due to contention caused by the traffic generated by the neighboring nodes. The traffic generated from the neighboring nodes contributes in the losses in two ways. First, it causes increase in collision which definitely increases the packet loss ratio. Secondly, it consumes the channel bandwidth. Active probing mechanism implemented in the design of ETT to capture the transmission rate may lead to over estimation during the time when the communication channels are quite busy.ETT is a metric that has been designed over ETX by adding bandwidth to ETX compute. ETT is an improvement over ETX as it includes the bandwidth in its computation [4].

3. Load aware expected transmission time (LAETT): It has incorporated the load balancing and link quality component in ETT to remove the drawback of ETT [10]. Load aware ETT is a combination of ETT and remaining capacity (RC) on the node. RC of link is used as load aware parameter to balance the traffic on the network. If two paths have same value of ETX then LAETT will prefer the paths having high value of RC. Loop free route or isotonic nature of the LAETT is due to the fact that it calculates the weights on each link. RC is designed to capture the total loads on the links and is defined as follows:

$RCj=Bj-\sum(fjk.yjk)$

Where *fjk* represents the transmission rates of the *Nj* flows,i.e., total number of current flows passing through node *j*.*Bj* indicates the transmission rate of node *j* and link quality factor of node j is represented by *yjk.*

LAETT is defined as follows:

$LAETTij=ETXij*S/ ((RCi +RCj)/2yij)$

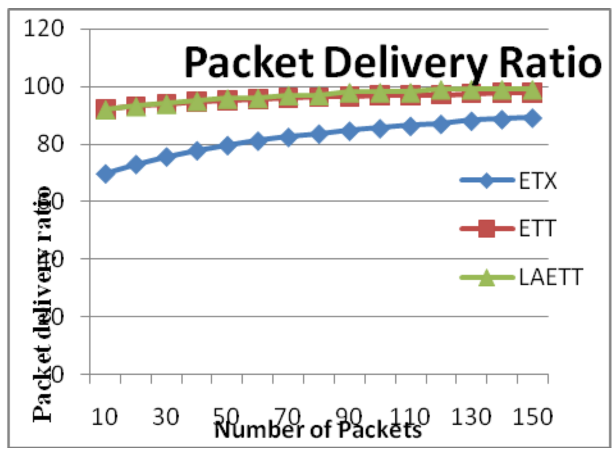
Whereas *Yij* is a link quality factor, *RCi* and *RCj* are the RC of the node *i* and *j*, respectively. Practically RC is calculated at layer 2 by measuring the free slots and completed slots provided by the modulation scheme in use. Transmission rate measurements in LAETT are carried out with the help of total number of flows passing across the node and are assumed to be of same data rate. This is actually not true in relation with the wireless networks as the data rates vary because of congestion and interference over the links from time to time. Moreover, different radios and applications utilizing the network have different transmission rate. Probing mechanism used in the design of LAETT to measure ETX may result in underestimation of the link quality.

III. METRICS ANALYSIS

Routing metrics for WMNs utilize transmission rate, packet loss ratio, and delay parameters to capture the link quality of the link, e.g., ETX, These routing metrics are simple in design and easy to implement in the routing protocol but they lack in capturing the load and aware parameters of the links. ETT metrics considers transmission rate with packet loss ratio, but lags behind in case of load aware. Load aware routing metrics, LAETT capture the traffic concentration and congestion parameters at node level to introduce load awareness in the routing which has a significant effect especially in multi casting and real time applications. ETX, ETT, LAETT are analyzed with performance parameters Packet delivery ratio, Throughput and bandwidth Utilization.

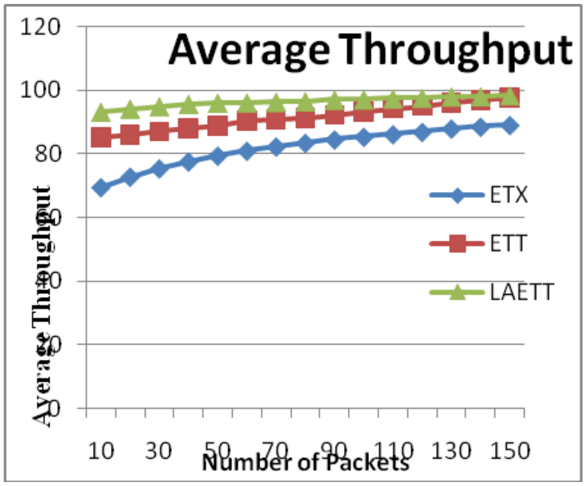
Packet Delivery Ratio: Packet delivery ratio is defined as the ratio of successfully delivered data packets.

$$Packet\ delivery\ ratio = \frac{(send\ packets - dropped\ packets)}{Send\ packets}$$



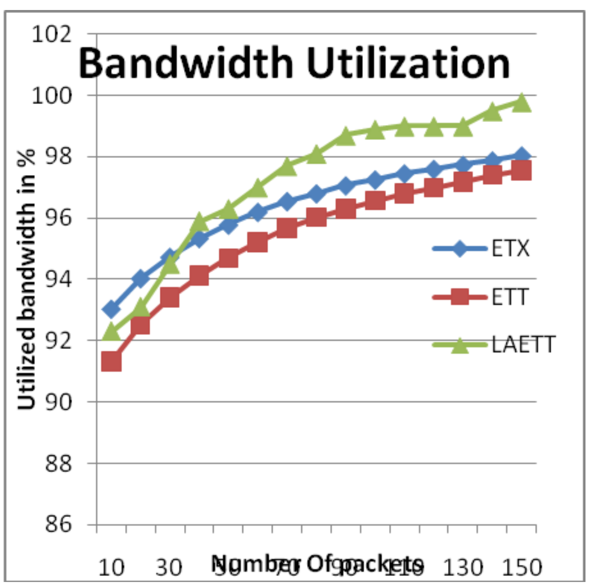
Throughput: Throughput is the total data packets received by the receiver at a particular Unit Time.

$$Throughput = bytes\ (received\ packets) * 8/\ (Finish\ time - Start\ time)$$



Bandwidth utilization: bandwidth utilization is defined as the efficient use of available bandwidth to achieve specific goal.

$$Bandwidth\ utilization = 100 - \frac{dpackets - data\ packets}{dpackets} * 100$$



IV. Conclusion

Quality of service is deployed by routing metrics in wireless mesh network ETX is routing metric simple in design and easy to implement in the routing protocol but they lack in capturing the load and interference aware parameters of the links. ETT is a metric that has been designed over ETX by adding bandwidth to ETX .ETT is an improvement over ETX as it includes the bandwidth in its computation. Load aware expected transmission time (LAETT) has incorporated the load balancing and link quality component in ETT to remove the drawback of ETT. ETT and LAETT show maximum packet delivery ratio, good average throughput, and efficient utilization of bandwidth as compared to ETX metrics.

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