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An Analysis of various routing metrics to enhance an efficient routing phenomenon in Wireless Mesh Networks

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Abstract- **Today internet has become an central part of our lives. It has a great increasing user community in many fields from transactions in the banking to the online entertainments. There are many wireless technologies which are used for the communication process over the internet. But Wireless Mesh Networks(WMNs) have been proved much promising and it has been widely used as it combines advantages of both Mobile Adhoc Networks(MANETs) and traditional networks. Routing in this WMNs is complex task so routing metrics which have a vital role in the routing process has become an interesting research concept from the last few years. In this paper we present the various routing metrics under active probing based approach with their performance and disadvantages and a idea towards future work.**

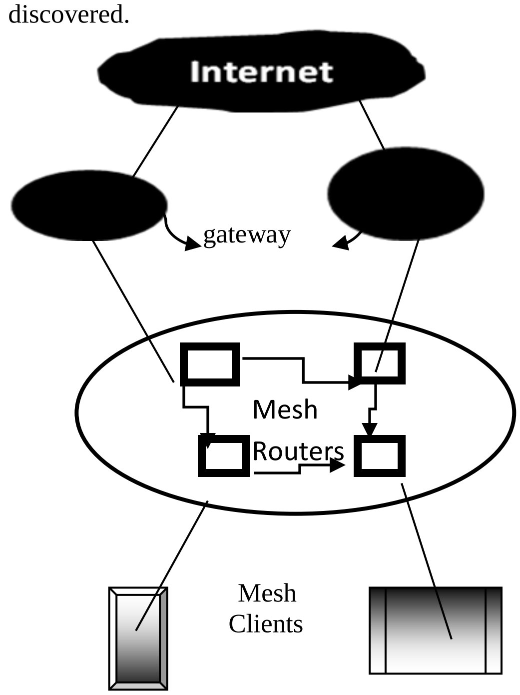
Keywords: Wireless mesh networks (WMNs),Routing metrics, hop count, ETX, ETT, WCETT

I. INTRODUCTION

Wireless mesh networks(WMNs)[1][2] consist of mesh routers and mesh clients, where mesh routers have very less mobility and these are the backbone of WMNs. Each node in the wireless mesh network serves as both host and also a router by forwarding data packets whenever the destinations are out of transmission range. The wireless mesh network is very dynamic network because it has the characteristics as self-organizing and self-configuring i.e., the nodes themselves create and maintain the mesh connectivity within the network. Due to these characteristics the advantages like low cost, easy maintenance, reliability and robustness enrich the wireless mesh networks.

Even with these characteristics of self-organizing the network can be deployed in an incremental way by introducing individual nodes. As number of nodes in the network increases the reliability and connectivity for the users also increases respectively. Currently there are numerous real time applications where this wireless mesh network has become a promising wireless technology. Some of the most popular applications are broadband home networking, community and neighborhood networks, enterprise networking, building automation, etc.

Routing[3][4] can be defined as the process of moving packets in a network from source nodes to destination nodes. Routing in wireless network is a very difficult task as the nodes in the network are not stationary. Routing in the wireless mesh networks has become a major research subject during the last decade. Whereas the main goal of the routing process is same for both the wired and wireless networks but new features of the wireless networks makes the routing problem more complex and interesting as well. Since the experience acquired by the wired networks is available it can be used just as a guide and new approaches and solutions have to be discovered.



Metric is an attribute which is used by the routing process. Among the number of routes discovered by the routing protocol the routing algorithm will select the optimal route based on the routing metric. The objective of the algorithm and metric may be to minimize the delay or maximize the network or path throughput or increase the probability of data delivery or distribute the traffic load equally.

Metric obtaining:

Many different ways are followed by the nodes for obtaining information used to calculate metric.

The information that consists about the details of number of interfaces, number of neighbor nodes, length of input and output queues is generally available at node after conducting the routing protocol operation. This is used for calculating metric in one of the methods.

In the other method the information after the observation of the traffic which combines both the incoming and outgoing traffic at a node without any active measurements along with the passive measurements is collected and used for computing metric. This is called passive computing.

In the active probing method special packets called probes are used for calculating the properties of link/path.

In this paper we present a study on wireless mesh networks and different routing metrics for these networks. In section 2 the basic operation, advantages and limitations of different active probing based metrics and default metric is explained. In section 3 a comparision table is provided. In section 4 disadvantages of existing metrics and an idea for future work is provided.

II. ROUTING METRICS

In this section we describe about different metrics proposed for wireless mesh networks. Initially, we discuss about the performance and disadvantage of the default metric known as hop count metric. Later we discuss about the most popular active probing based metric.

A. Hop count:

The concept behind hop count metric is very simple. In this metric every link is termed as a hop and each hop is equal to one unit. Among all the routes that are available the route which consists of minimum number of hops is selected without considering the quality or any other characteristics of the link.

The implementation of this hop count metric is very ease this is the for which it is widely used in wired networks. This metric is the default metric in both wired and wireless network routing protocols. The popular protocols which use this metric as default metric both implicitly and explicitly are OLSR[5], AODV[6], DSDV[7] and DSR[8].As it considers very few hops from source to destination the advantages that involve with this concept are smaller delay and reduced waste of network resources etc.

It also includes some disadvantages because it does not consider the other characteristics like link quality, traffic and many other factors that effect connectivity between the nodes.

B. Active probing based metrics:

Probing arises new challenges[3]. For instance the probe packets should be treated as normal traffic packets and those packets should not be preferentially treated in the network. At the same time themselves increases the amount of traffic.

On the other hand, the probing based metrics have proved capable in the wireless mesh networks. The main reason for which these probing based metrics have been popular is that they do not rely on analytical assumptions or indirect measurements instead they directly measure the quantity of interest. Here are the most popular and widely spread active probing based metrics.

1) Expected Transmission Count (ETX):

By observing that hop count metric does not provide optimal route De Couto [9] has proposed a novel active probing based metric called ETX i.e., Expected Transmission Count. ETX maintains an approximate value of the number of transmissions along with the retransmissions and assumes that this number of transmissions are needed to send a packet from source to destination. It selects only the route that allows these many transmissions and if possible less than the approximated value but never more. This metric not only minimizes the number of transmissions but also consumes less energy.

Let f_d be the forward delivery ratio and r_d be the reverse delivery ratio. Then the probability of sending the data and receiving acknowledgement is $f_d \cdot r_d$. The assumption followed here is that every effort made to transmit the packet will be independent of its previous effort. Based on this assumption the number of transmissions are estimated as:

$$ETX = \frac{1}{f_d \cdot r_d}$$

The major advantage with this ETX is it is independent of the link load. The disadvantages of this metric it does not calculate the loss rate exactly and it does not even reduce the intra-flow interference.

2)Expected Transmission Time (ETT):

Draves [10] observed that ETX does not work well in some situations. From this observation a new metric named ETT which means Expected Transmission Time has taken birth. The ETT is calculated as follows:

$$ETT = ETX * \frac{P}{C}$$

Where
P is the size of the packet and
C is the measured capacity of the link.

As it computes the capability of the link only high throughput paths are selected so the performance of overall network is increased. This is the main advantage of ETT metric. It also contains some disadvantages like it also does not try to reduce to intra-flow interference and also inter-flow interference.

3) Weighted Cumulative Expected Transmission Time (WCETT):

WCETT [11] considers the diversity of the channels and it was proposed to improve the ETT metric in multi radio mesh networks. The WCETT metric of a path p is computed as follows:

$$WCETT_p = (1-\gamma) * \sum ETT + \gamma * MaxX_j$$

Where,
X_j = summation of links ETT values which are on channel j in a system having orthogonal channels.

$$X_j = \sum_{hops\ on\ channel\ j}^{n} ETT_i \; 1 \leq j \leq k$$

γ is a tunable parameter between 0 and 1 which controls the preferences over the path length versus channel diversity.

Though the performance of the mesh network is much improved with the origin of WCETT metric than previous metrics like hop count, ETX, ETT but still this metric also have some disadvantages. The main drawback of the WCETT metric is that it does not compute the link connectivity exactly at the current situation and it also failed to capture the inter-flow interference.

4) Metric Of Interference And Channel Switching (MIC):

As the evolved metrics failed to overcome the problem of inter-flow and intra-flow interference MIC[12] came into existence to solve this problem. The MIC of a path p is calculated as follows:

$$MIC(p) = \frac{1}{T * \min(ETT)} \sum_{link\ l \in p} IAR_l + \sum_{node\ i \in p} CSC_i$$

Where T is the total number of nodes and smallest ETT is considered as min(ETT). The interference aware resource usage(IAR) and channel switching cost(CSC) are the two important components of MIC and they are defined as follows:

$$IAR_l = ETT_l \times T_l$$

$$CSC = \begin{cases} m1 \text{ if } CH(pr(i)) \neq CH(i) \\ m2 \text{ if } CH(pr(i)) = CH(i) \end{cases}$$

$0 \leq m1 \leq m2$,

Here the transmission on link l interferes with the neighboring nodes N_l and CH(i) represents the node i's channel.

The performance is much better in the case of interference while using MIC metric but the main disadvantage is that it is a big overhead to compute MIC metric for each path.

5) Metric Based On Interference And Load(MIL):

The idea of concentrating on both interference and load have given birth to MIL metric[13] . The MIL metric calculated as follows:

$$MIL(p) = \sum_{l \in p} \overline{L_l} \times \frac{S}{B_l}$$

Where S is the size of the packet and $\overline{L_l}$ is the average load of link l. As the load has great effect on network performance so instead of direct load an average load value is considered. The average load value is obtained in the following manner:

$$\overline{L_l} = (1-\alpha) \times L_{l-c} + L_{l-p}$$

Where α is the moving exponent. L_{l-c} is the current sample load value and L_{l-p} is the previous value. B_l which is bandwidth of link l is obtained by using the interference values of link l's previous link j and its previous link I as:

$$B_{\downarrow}l = \{■(B_{\downarrow}(inter, l) \;\; CH(l) \neq CH(j), CH(l) \neq CH(i) @ (B_{\downarrow}(inter, i$$

Here B_{ij} is the bandwidth of the virtual link under various interferences.

$$B_{ij} = \frac{B_{inter,i} \times B_{inter,j}}{B_{inter,i} + B_{inter,j}}$$

Where $B_{inter,i}$ is the bandwidth of a link under interference calculated using channel busy time CT nominal link data rate NDR and interference ratio RI:

$$B_{inter,i} = (1 - CT_i) \times NDR \times RI_i$$

Where

$$CT_i = \frac{TT - IT}{TT}$$

TT=Total Time
IT=Ideal Time
Ratio of the interference is he ratio for signal to interference plus noise ratio and signal to noise ratio:

$$RI_i = \frac{SIN_i}{SN_i}$$

MIL metric recognizes the path with high traffic and load and it diverts the packet through low interference paths which results in minimum delay etc.

III. COMPARISION

S.NO	METRIC	QUALITY RATE	PACKET-SIZE	INTRA-FLOW INTERFERENCE	INTER-FLOW INTERFERENCE
1	Hop count	***	***	***	***
2	ETX	√	***	***	***
3	ETT	√	√	***	***
4	WCETT	√	√	√	***
5	MIC	√	√	√	√
6	MIL	√	√	√	√

IV. CONCLUSION

In this paper we discussed about different routing metrics of wireless mesh networks which are mainly on the basis of active probing. Though these metrics are very popular they also put up with the problems of inaccuracy and responsiveness of the network. So the future work can be carried out on concentrating much more on interference and as metrics like MIL are proposed under the assumption of considering only orthogonal channels so in the higher developments the partially overlapped channels may also considered and research may be carried out.

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