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An Effective Implementation of Load Balanced Routing Scheme for Wireless Mesh Networks Using ETT-LB Metric

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Abstract

Wireless mesh network is emerged as a response to the growing demand for high throughput multimedia applications over wireless mesh networks. The core technology involves a network of wireless routers forwarding each other's packet in a multi hop fashion. Mesh networks promises fast, easy and economical network operation, and this is the main reason for opting mesh network as a means for internet connectivity for a wide range of users. As a result the gateway nodes will become congested due to high traffic load towards the outside networks. Therefore a routing scheme is essential for the global load balancing across the network while ensuring high throughput paths. This paper introduces a routing scheme which balances the load in the network and provides high throughput path. Here we use the ETT-LB metric augmented with load factor for optimal path selection.

Keywords: Wireless mesh networks, Throughput, Multi hop, Gateway, ETT-LB.

Introduction

A wireless mesh network (WMN) is a communication network made up of radio nodes organized in a mesh topology. Wireless mesh networks often consist of mesh clients, mesh routers and gateways. Each network user is also a provider, forwarding network packets to the next node. The infrastructure of the network is decentralized and simplified because each node needs to transmit only to the next node [1]. Wireless mesh networking allows people living in remote areas and small businesses operating in rural neighborhoods to connect their networks together for affordable Internet connections.

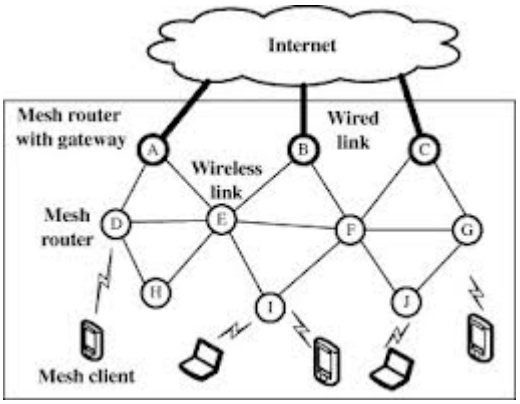


Fig 1: A three layer wireless mesh architecture

In recent years wireless mesh network has been drawing significant attention since its flexibility in providing wireless backbone for wired back bone. The potential applications of wireless mesh networks such as multimedia applications, public safety, instant surveillance systems, and high speed metropolitan area networks demands high throughput paths for their efficient operation [2]. The challenges faced by WMN are load balancing, optimal routing, fairness etc .Existing solutions in other wireless network cannot be directly applied to mesh network due to the difference in traffic patterns, mobility scenarios, gateway functionalities and bandwidth requirements.

Most of the users are principally interested in accessing high speed broadband connection or other commercial servers. Therefore the traffic is routed either towards the internet gateways or from the gateways to the clients. Thus if routers in the mesh network simply select a high throughput path to the gateway, the traffic in this path will tremendously increase and as a result the gateways become overloaded which will reduces the overall performance of the network. In a wireless mesh network the traffic load is unequally distributed across the network. This load imbalance can be resolved by a routing scheme which considers load factor in to account. A load aware routing scheme is proposed in [12] which considers the load factor and provides optimal path. But it considers only the load and end to end delay while routing which prevents from yielding high throughput paths. In our proposed routing scheme we use the ETX metrics augmented

with load factor which is responsible for getting high throughput congestion free paths.

Related Work

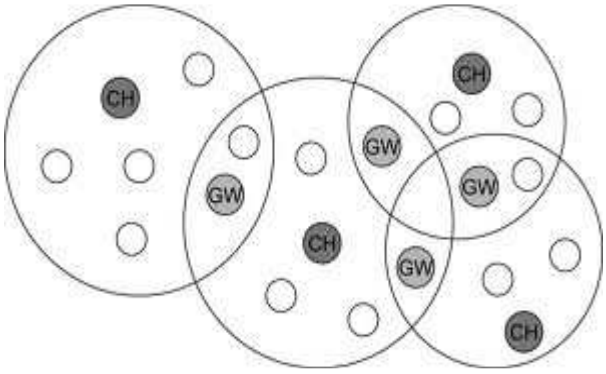
Management and efficient operation of wireless mesh network has been an active research area and a number of routing algorithms and metrics have been proposed. The first routing metric is the Expected Transmission Count ETX [3] which helps to find high throughput path selection between the source destination pairs.ETX accounts for the expected number of transmissions required to deliver a packet to the neighbor. In [4], the authors propose a medium time metric (MTM) for the multi rate network. The Expected Routing Time [ETT] metric proposed in [5] is a combination of ETX and MTM.WCETT metric is a modification of ETT to consider the intraflow interference.

The load aware routing metrics such as DLAR, LBAR, ART, WCETT-LB and QRCCLB considers load factor into their routing scheme. The dynamic load-aware routing (DLAR) in [6] takes the number of packets queued in the node interface as a routing metric. The authors of [7] propose load-balanced ad-hoc routing (LBAR) which counts the number of active paths on a node and its neighbors and it is used as a routing metric. The primary aim of LBAR and DLAR is to reduce the packet delay and packet loss ratio and it is designed for ad-hoc networks. An admission control and load balancing algorithm for wireless mesh network is proposed in [8].Here an available radio time (ART) is calculated for each node and at the time when a new connection is requested, a route with largest ART is selected. WCETT-LB proposed in [9] is a modification of WCETT metric by adding load factor consisting of the average queue length and the degree of user satisfaction. In [10] a QoS aware routing algorithm with congestion control and load balancing (QRCCLB) is proposed, which calculates the number of congested nodes on each route and chooses a path among them with the smallest number of congested nodes.

Compared to these load aware routing protocols the proposed scheme has several advantages such as lower load in the cluster head and ensuring high throughput and less congested path to reach the destination.

Proposed Routing Scheme

In our proposed routing scheme the mesh network is divided into multiple overlapping clusters. A cluster head is selected which takes the role of controlling the traffic load on the wireless links. The load in the cluster is the sum of the load in the links of the cluster.



CH: Cluster Head GW: Gateway

Fig 2: Clustered mesh network

The Routing scheme is divided into two phases load calculation where total load in the cluster is estimated and in the routing phase the source station will select a path having high throughput and less congestion.

A. Load Calculation

Airtime ratio of the link represents the traffic load in the network. It can be defined by the following equation [11]

$$Load = \frac{\text{Sum of the data rates on the link}}{\text{Effective transmission rate of the link}} \text{----- (1)}$$

The effective transmission rate of the link is assumed to be the Shannon capacity of the link [12].If the sum of the airtime ratios of the link in a cluster exceeds a certain threshold limit; the cluster can be regarded as overloaded.

B. Routing

In the load aware routing scheme proposed by [12], the routing phase considers only the end to end delay on the route and the load. Since the mesh network is mainly developed to support high throughput multimedia applications the selection of high throughput path is important. In our proposed routing scheme we use ETT-LB [13] metric augmented with the load factor for routing which ensures the selection high throughput and less congested path towards the destination. ETT-LB is a modification of Expected Transmission Time (ETT) metric by integrating a load balancing component to it. ETT metric is defined as the transmission time for the successful delivery of packet. Here the expected transmission time is equal to the fraction of effective transmission time of a link. The Shannon's link capacity (d_l=20 log 2(1+SNR$_l$)) will give the effective transmission time of a link. When a cluster is found to be overloaded the cluster head will increase the link cost. A path with minimum link cost is selected as the optimal path. For calculating the link cost we incorporate the ETT-LB metric with the load factor. ETT-LB metric is given by the following equation

$$ETT\text{- }LB(p) = (1-\beta) \sum_{linkl} ETT_l + \beta \sum_{linkl} EDT_l \text{-----(2)}$$

$EDT_l = (Data_l / Bandwidth_l)$----------(3)

Where Where β is a tunable parameter subject to $0 \leq \beta \leq 1$. The continuous load transmission time of each node *i* is considered by using $Data_i$. Expected Delay Time (EDT) is the average link load at a node. We take the fraction of average link load over the transmission rate to get the actual time needed for continuous load transmission. This will entails that a path with low ETT-LB value has low congestion, low packet loss ratio and hence high throughput.

Unlike the scheme proposed in [12] the link cost used for routing incorporates ETT-LB metrics. Thus when the cluster head estimates a high traffic load the path with lowest link cost is selected as the optimal route. Therefore the proposed scheme will yield a path having high throughput and less congestion.

Performance Evolution

For simulating the proposed routing scheme Network Simulator (NS2) is used. The simulation topology is a wireless topology. Additionally, simulation uses a TCP traffic mode with a constant bit rate.

Simulation Specifications

Simulator	: NS2
Area	: 1000mx1000m
No of nodes	: 50
Transmission range	: 250
Packet size	: 512 bytes
Mac Protocol	: 802.11

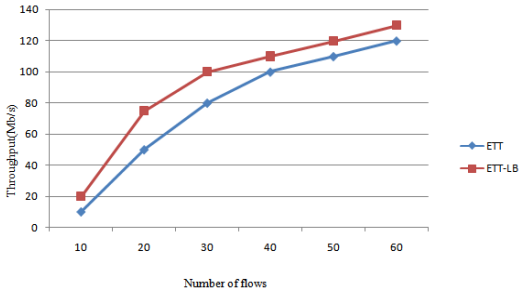


Fig :2 System Throughput

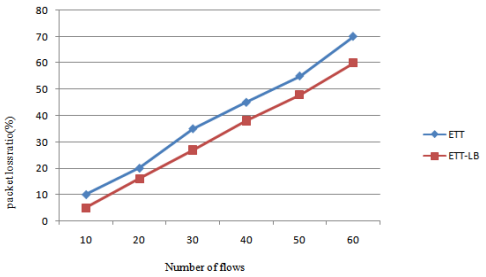


Fig:3 Packet loss

Here considered different flows and for each flow we estimated the load on each cluster head and compares with the scheme which uses the link cost with ETT routing metric and the result shows that the proposed scheme with ETT-LB metric improves the throughput and the packet loss ratio and hence better balances the load.

Conclusion

In this paper we proposed a load control routing scheme for wireless mesh networks. We uses a new routing metric ETT-LB for load balancing. Evaluation results show that the ETT-LB routing metric has good performance for Load-Balance. In this work, only a single channel is being considered. In future work, the proposed metric which will be considered is a multi channel.

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