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Enhanced Intra-Cluster Network Routing Scheme for Efficient Wireless Mesh Network

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Abstract. This paper proposes a load control routing scheme for intra cluster routing in wireless mesh networks. Unlike other existing schemes proposed for load balancing for wireless mesh networks, this routing scheme implements in a different manner for both Inter-cluster and Intra-cluster routing based on Load Aware Routing by forming a Virtual Network and use the free nodes inside the cluster to route the data instead of cluster head. This method reduces the load on the respective cluster head, which is used for efficient Inter-cluster routing. This improves performance of the network increases. We prove through simulations that load on the particular cluster head is reduced by taking number of flows into account.

Keywords: wireless mesh networks, load-balancing, inter-clustering, intra-clustering.

1. 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. In this network nodes act as routers to transmit data from nearby nodes to distances. One of the main concerns for wireless mesh networks is the reduction of the overall network capacity due to the interference between adjacent nodes. In a wireless mesh network traffic load tends to be unevenly distributed over the network. In this situation the utility of the network had been decreased.

In the WMN, a great portion of users intends to communicate with outside networks via the wired gateways. In such environment, the wireless links around the gateways are likely to be a bottleneck of the network. If the routing algorithm does not take the account of the traffic load, some gateways may be overloaded while the others may not. This load imbalance can be resolved by introducing a load-aware routing scheme that adopts the routing metric with load factor. When the load-aware routing algorithm is designed to maximize the system capacity, the major benefit of the load-aware routing is the enhancement of the overall system capacity. Although there have been some works on load-aware routing for mobile ad-hoc networks and WMN's, they simply include some load factors in the routing metric without consideration of the system-wide performance.

In this paper , we proposes a load control routing scheme for intra cluster routing in wireless mesh networks, which maximizes the overall network performance. We can implement this routing scheme by forming virtual network. Using this method, we can not only reduce the load on the cluster head but also reduces the end-end delay in the network.

The paper is organized as follows: Section 2 gives the related works, Section 3 presents the existing system and its drawbacks, and Section 4 presents the proposed system with the support of results presented in section 5. Section 6 concludes the paper.

2. Related Work

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In this section we will briefly discuss recently proposed routing metrics for WMNs. Routing metrics are very critical for determining the performance of the networks. A good metric should contain sufficient information about the link or the routing path. Each node in the network chooses the best path in terms of all the properties contained in routing metric. Recently proposed routing metrics for mesh networks include hop count, Expected Transmission count (ETX), Expected Transmission Time (ETT), Weighted Cumulative ETT (WCETT) and Metric of Interference and Channel-switching (MIC).

The load-aware routing protocols incorporate the load factor into their routing metrics. The dynamic load-aware routing (DLAR) takes as the routing metric the number of packets queued in the node interface. The load-balanced ad hoc routing (LBAR) counts the number of active paths on a node and its neighbors, and uses it as a routing metric. Both the DLAR and LBAR are designed for the mobile ad hoc network, and aim to reduce the packet delay and the packet loss ratio. In an admission control and load balancing algorithm is proposed for the 802.11 mesh networks. In this work, the available radio time (ART) is calculated for each node, and the route with the largest ART is selected when a new connection is requested. This algorithm tries to maximize the average number of connections. The WCETT-LB is the WCETT augmented by the load factor consisting of the average queue length and the degree of traffic concentration. The QoS-aware routing algorithm with congestion control and load balancing (QRCCLB) calculates the number of congested nodes on each route and chooses the route with the smallest number of congested nodes.

Compared to these load-aware routing protocols, the proposed routing scheme has major advantages. First, the proposed scheme is design to reduce the load on the cluster head, which is useful for efficient inter-cluster routing. So, that performance of the network increases. Second, the proposed scheme also reduces the end-end delay between the nodes in intra-cluster routing.

3. Load-Aware Routing Scheme

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The load aware routing scheme estimates the traffic load in each cluster. The traffic load in a cluster is the sum of the traffic load on the links in the cluster. If the traffic load in a cluster is estimated to be too high, it can redirect the routes passing through the overloaded cluster for load balancing. The airtime ratio of a link represents the traffic load on the link. It can be defined as Eq.1:

$$Load = \frac{\text{sum of the data rates on the link}}{\text{effective transmission rate of the link}} \tag{1}$$

If the sum of the airtime ratios of the links in a cluster exceeds a certain bound, the cluster can be regarded as overloaded. This routing scheme is implemented by using Dual decomposition method; it achieves load balancing in distributed way. One of the major problems with this Dual decomposition method is route flapping problem. This routing scheme overcomes the route flapping problem by using the Dampening algorithm

3.1. Dampening algorithm

Dampening algorithm updates the active route only when the load on the current route crosses certain margin. The load-aware routing scheme follows the following steps for the control information exchange

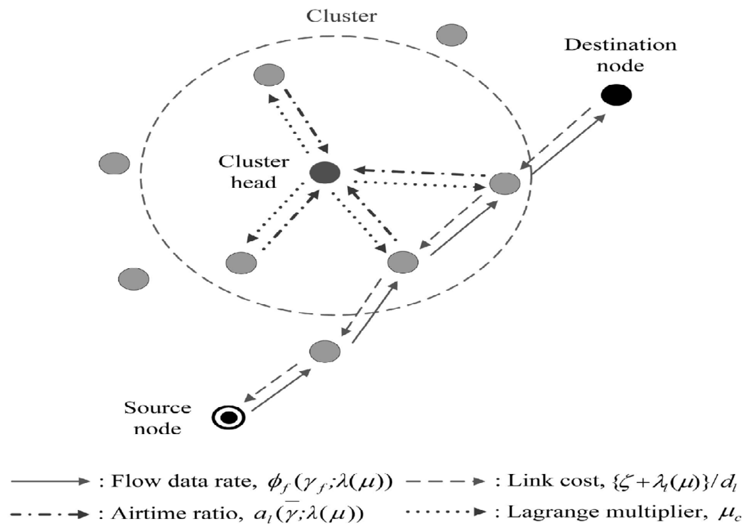

Fig. 1: Control information exchange for distributed implementation

- The source node of flow sends a message containing flow data rate to the node on the active route.
- Each node calculates the traffic load for all the outgoing links and broadcast them to heads of clusters to which that belongs to.
- The cluster head receives traffic load for all links in its cluster and update the load on the cluster head.
- The cluster head broadcast the updated load to transmitter nodes of the links in its cluster.
- Each node calculates the link cost for all the outgoing links.
- The source node of flow finds optimal route when each node updating its link cost for all the outgoing links.
- The source node of flow sets active route to Optimal route when the network utility is greater by considering the optimal route than that of the current active route Otherwise the active route can't be changed.

In this scheme, the same principle is applied for both inter-cluster routing and intra-cluster routing. So, the load faced by the cluster head will be more in inter-cluster routing, if the cluster head is again used for intra-cluster routing in that case the cluster head may be overloaded. This may lead to the decline of network performance. To overcome these drawbacks, we propose a routing scheme which applies in a different manner for inter-cluster and intra-cluster routing based on load-aware routing scheme.

4. Proposed Intra-cluster Routing Scheme

In the proposed routing scheme, a WMN is divided into multiple overlapping clusters. A cluster head takes role of controlling the traffic load on the wireless links in its cluster. The cluster head periodically estimates the total traffic load on the cluster and increases the "link costs" of the links in the cluster, if the estimated load is too high. In this scheme, each user chooses the route that has the minimum sum of the link costs on it. Thus, a user can circumvent overloaded areas in the network, and therefore, the network-wide load balancing can be achieved.

This routing scheme is implemented in a different manner for inter-cluster and intra-cluster routing by forming virtual networks that is in the case of intra-cluster routing we can use the free nodes within the cluster to route the data instead of cluster head, for inter cluster routing it follows the load-aware routing scheme. By applying this method we can reduce the load on the particular cluster head.

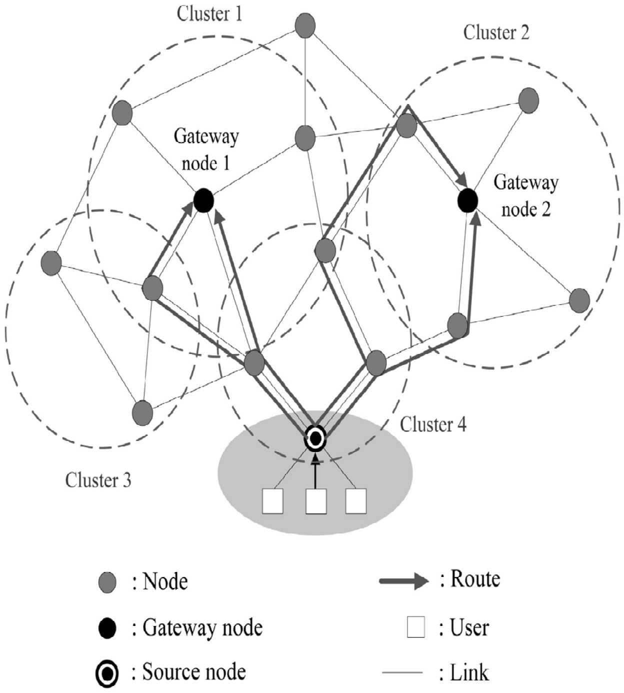

Fig. 2: Mesh Network Example

4.1. Inter-cluster routing

First, the source node sends RREQ message to the cluster head to which it belongs to, and then the cluster head broadcast the RREQ to the cluster heads with in the transmission range of that cluster head. The destination node cluster head replies with the route RREP message. After that, the source node sends the data to the cluster head, the cluster head forwards it to the destination node cluster head from that to the destination node within that cluster.

4.2. Intra-cluster routing

In this section we explain the implementation of the routing scheme for intra-cluster routing. First, the source node broadcast a route request packet to the cluster head; if it gets the route reply packet from the node within cluster in that case we consider that cluster as Virtual network. So, the source node directly sends the data to the destination node without using the cluster head.

Load on the particular link is calculated as:

$$\frac{arrivaltime[10]}{time[10]-time[0]} \tag{2}$$

By knowing the load on each link we can choose the optimal route to send the data and we can also known that whether the particular cluster is overloaded or not.

5. Simulation Results

5.1. Simulation specifications

OS	: Red hat Linux 9
Simulator	: NS2
Topology	: Wireless topology
Number of nodes	: 24
Radio Transmission Range	: 250m
Simulation time	: 40 sec
Area of the Network	: 1000m*1000m

5.2. Simulation results

Network Simulator (NS2) is used for simulating the existing and proposed systems.NS2 is an IEEE standardized simulator for simulating Networks. Consider different flows for each flow we estimated the load on the cluster head and compares load on the cluster head for both load-aware routing scheme and intra-cluster routing scheme with respect to the no of flows.

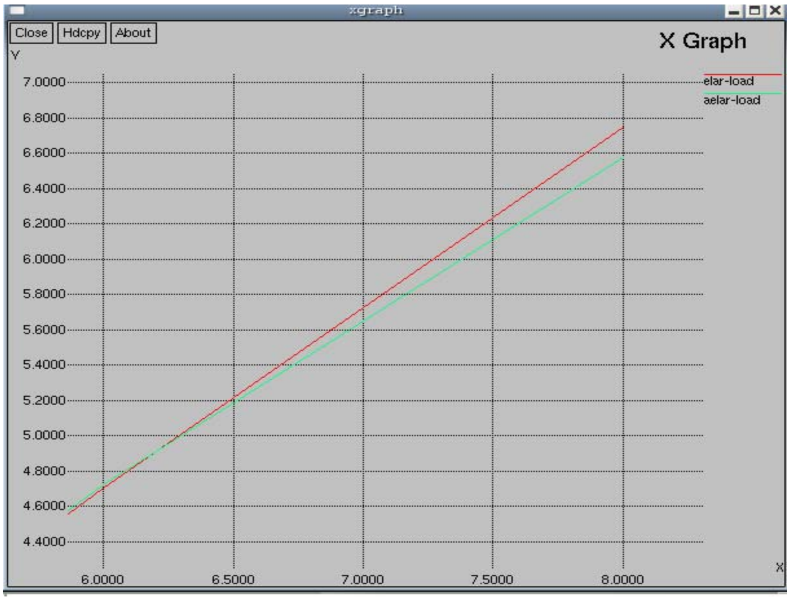

Fig. 3: No. of flows vs Load on the cluster

The Fig.3.Graph contains two routing protocols load on the cluster head. In the graph Efficient Load-Aware routing scheme is represented by red line and Load control for intra-cluster routing is represented by green line. The simulation results in the Figure 2. Show that the load on the cluster is reduced by using the load control for intra cluster routing than that of the Efficient Load-Aware routing scheme.

6. Conclusion

In this paper we proposed a load control routing scheme for wireless mesh networks. The intra-cluster routing is implemented by forming virtual networks. This is quiet efficient than that of the Efficient Load-Aware routing Scheme. This can reduce the load on the cluster head in intra-cluster routing; this is useful for efficient inter-cluster routing. So, the Overall network performance increases.

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