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Efficient Cluster Based Congestion Control in Wireless Mesh Network

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ABSTRACT

A Wireless Mesh Network (WMN) is a communication network made up of radio nodes, organized in a mesh topology. In this mesh network, load balancing can be used to extend the lifetime of a mesh network and thus reducing the traffic congestion and improves the network performance. The clustering techniques are used to solve routing and congestion control problems, because it offers scalability and enhance the availability of network and reduce overhead. Here a Weighted Clustering Algorithm (WCA) method is selected to divide the network into k –cluster to manage the load in small scale and hence to reduce the overhead. The node with maximum weight is more desirable to select as Cluster Head (CH).By using the AODV protocol a node in the cluster sends many small packets compared to other reactive protocols to increase the speed of the transmission packet. When the network size increases, the degree of node also increases causing network congestion. The use of this WCA reduces this overhead by allowing route discovery and maintenance.

Key Words: *Mesh network, overhead, congestion, weighted clustering algorithm (WCA), Cluster Head (CH)*

1. INTRODUCTION

Wireless Mesh Networks (WMNs), consisting of wireless access networks interconnected by a wireless backbone, Present an attractive alternative. Compared to other networks, WMNs have low investment overhead and can be rapidly deployed. The wireless infrastructure is self-organizing, self-optimizing, and fault tolerant.A WMN is dynamically self-organized and self-configured, with the nodes in the network automatically establishing and maintaining mesh connectivity among themselves (creating, in effect, an ad hoc network). This feature brings many advantages to WMNs such as low up-front cost, easy network maintenance, robustness, and reliable service coverage. As per [1,2] F. Akyildiz, X. Wang and W. Wang a typical WMNs, nodes are comprised of mesh routers and mesh clients. Each node operates not only as a host but also act as a router, forwarding packets on behalf of other nodes that may not be within direct wireless transmission range of their destinations. They have a wireless infrastructure and work with the other networks to provide a multi-hop internet access service for mesh clients. On the other hand, mesh clients can connect to network over both mesh routers and other clients. In these networks, due to large number of nodes, working through some issues like security, scalability and manageability is required. Thus, new applications of WMNs make secrecy and security mechanisms are necessities. Routing is an important factor to forward the data packet from source to destination node.

To guarantee good performance, routing metrics must satisfy these general requirements are scalability, reliability, flexibility, throughput, load balancing, congestion control and efficiency. The routing metrics for mesh routing protocols are Hop Count, Blocking Metrics, Expected Transmission Count (ETX), The Expected transmission time (ETT), The Weighed Cumulative ETT (WCETT) .As per [3] Adebanjo Adekiigbe ,Kamalrulnizam Abu Bakar and Ogunnusi Olumide Simeon says that in any networks, congestion occurrence is a common phenomenon, this is when resource demands in the network exceed the capacity the network can provide and the packets loss is experienced. This has been a menace that many authors have proposed different solutions based on the topologies and applications need. Recent approach to solve the congestions problem in WMNs adopts cluster based solutions. The purpose of this study is to reveal the strong and weak points of some of these cluster based solutions so that researchers can come up with broader approach to tackle the inherent problems of congestions and load balancing in an ad hoc network like WMNs.

2. CLUSTERING TECHNIQUE

Cluster and clustering are words that are used broadly in computer networking to refer to a number of different implementations of shared computing resources .Typically, a cluster integrates the resources of two or more computing devices that could otherwise function individually, together for some common purpose. Clustering of wireless network nodes into groups with proper cluster head (CH) selection will impose a regular structure in the network and makes it possible to guarantee basic levels of system performance such as throughput and delay, even in the presence of mobility, energy resources and a large number of mobile nodes. However, mobility and energy resources are not major issues in infrastructure WMNs.

Cluster algorithms may be used in improving database access and network performance. As per Mahdieh Sasan,Farhad Faghani, the network performance metrics such as routing delay, bandwidth consumption, energy consumption, throughput, and scalability are highly improved with appropriate clustering techniques. A clustering algorithm splits the network into disjoint sets of nodes, each centering on a chosen cluster-head [8]. The clustering algorithms are

2.1 Highest-Degree heuristic

The Highest-Degree, also known as connectivity-based clustering, was originally in which the degree of a node is computed based on its distance from others. Each node broadcasts its id to the nodes that are within its transmission range. A node *x* is considered to be a neighbor of another node *y* if *x* lies within the transmission range of *y*. As per Gerla and J.T.C. Tsai, the node with maximum number of neighbors (i.e., maximum degree) is chosen as a clusterhead and any tie is broken by the unique node ids. The neighbors of a clusterhead become members of that cluster and can no longer participate in the election process [9]. Since no clusterheads are directly linked, only one clusterhead is allowed per cluster. Any two nodes in a cluster are at most two-hops away since the clusterhead is directly linked to each of its neighbors in the cluster. Basically, each node either becomes a clusterhead or remains an ordinary node (neighbor of a clusterhead). Experiments demonstrate that the system has a low rate of clusterhead change but the throughput is low under the Highest-Degree heuristic [15]. Typically, each cluster is assigned some resources which is shared among the members of that cluster on a round-robin basis. As the number of nodes in a cluster is increased, the throughput drops and hence a gradual degradation in the system performance is observed. The reaffiliation count of nodes is high due to node movements and as a result, the highest-degree node (the current clusterhead) may not be re-elected to be a clusterhead even if it loose one neighbor. All these drawbacks occur because this approach does not have any restriction on the upper bound on the number of nodes in a cluster.

2.2 Lowest-ID heuristic

The Lowest-ID, is as known as identifier-based clustering. This heuristic assigns a unique id to each node and chooses the node with the minimum id as a clusterhead. Thus, the ids of the neighbors of the clusterhead will be higher than that of the clusterhead. However, the clusterhead can delegate its responsibility to the next node with the minimum id in its cluster. A node is called a gateway if it lies within the transmission range of two or more clusterheads. Gateway nodes are generally used for routing between clusters. Only gateway nodes can listen to the different nodes of the overlapping clusters that they lie. The concept of distributed gateway (DG) is also used for inter-cluster communication only when the clusters are not overlapping. DG is a pair of nodes that lies in different clusters but they are within the transmission range of each other. The main advantage of distributed gateway is maintaining connectivity in situations where any clustering algorithm fails to provide connectivity. For this heuristic, the system performance is better compared with the Highest-Degree heuristic in terms of throughput [9]. Since the environment under consideration is mobile, it is unlikely that node degrees remain stable resulting in frequent clusterhead updates.

However, the drawback of this heuristic is its bias towards nodes with smaller ids which may lead to the battery drainage of certain nodes. One might think that this problem may be fixed by renumbering the node ids from time to time, which is however non-trivial. There are other problems associated with such renumbering. For instance, the optimal frequency of renumbering would need to be determined so that the system performance is maximized. More importantly, every time node ids are reshuffled, the neighboring list of all the nodes needs also to be changed. If we consider that the nodes are numbered in the increasing order of their remaining battery power, then a centralized algorithm is required. We can avoid this by exchanging ids between nodes and making sure that the uniqueness of ids is maintained. Even then, the clustering has to be redone which would add unnecessary computational complexity to the system. For example, suppose two nodes mutually exchange their ids in order to keep the ids according to their remaining battery power. This effect may propagate and add overhead to the system. Moreover, it does not attempt to balance the load uniformly across all the nodes.

2.3 Distributed Clustering Algorithm

As per S. Basagni the Distributed Clustering Algorithm (DCA) is suitable for clustering ad hoc networks, in which nodes assumes quasi-static or moving at a very low speed. DCA uses weights associated with nodes in electing cluster heads. The DCA makes an assumption that the network topology does not change during the execution of the algorithm. A node waits for all its neighbors with higher weights to decide to be CHs or join existing clusters. Nodes possessing the highest weights in their one-hop neighborhoods are elected as CHs [4]. Whenever a node receives multiple CH announcements, it arbitrates among these CHs using a preference condition (such as a node with higher weightwins). If none of the higher-weight neighbors of a node decides to become a CH, then this node decides to become a CH. The protocol is fully distributed and efficient, as it exhibits some great features that make it scale large enough for wireless mesh network. It incurs very limited bandwidth cost since each node broadcasts one, and only one, message. This latter is sent when the node determines its cluster, thereafter, the algorithm stops [13]. The iterative approaches experience the problem of convergence speed which is dependent on the network diameter (path with the largest number of hops). Despite slow iteration convergence speed, the performance of iterative techniques is also highly sensitive to packet losses.

2.4 Weighted Clustering Algorithm

As per Chatterjee M., Das S. K. and Turgut D, The Weighted Clustering Algorithm [5,6] elects a node based on the number of neighbors. The algorithm takes into consideration the number of nodes a CH can handle ideally without any severe degradation in the performance, transmission power, mobility, and battery power of the nodes. Unlike other existing schemes which are invoked periodically resulting in high communication overhead, the algorithm is adaptively invoked based on the mobility of the nodes [5,6]. Computation cost is reduced by CH election procedure as long as possible while load balancing is achieved by specifying a predefined threshold on the number of nodes that a CH can effectively handle. While this guarantees that none of the CHs are overloaded at any instance of time, the load balancing factor (LBF) to measure the degree of load balancing among the CHs is generated as a performance metrics. This algorithm helps to control congestion; however, node mobility computation will severely affect the overhead cost and may even introduce enormous traffic that may cause congestion in WMNs.

3. PROPOSED WCA BASED ON AODV PROTOCOL

3.1 Clustering Algorithm Design Goal

It is intended to integrate clustering with routing functions [7]. The design aims of our clustering scheme include:

1. An algorithm using a routing protocol's control messages to form clusters with limited overhead.

2. clustering algorithm operating in localized and distributed manners and intertwining with nodes using only AODV.

3. The algorithm incurring limited cluster formation/maintenance overhead and supporting formation of on-demand clusters.

4. The algorithm minimizing network-wide flooding and being scalable.

3.2 Weighted Clustering Algorithm (WCA)

None of the above heuristics leads to an optimal selection of clusterheads since each deals with only a subset of parameters which impose constraints on the system. For example, a clusterhead may not be able handle a large number of nodes due to resource limitations even if these nodes are its neighbors and lie well within its transmission range. Thus, the load handling capacity of the clusterhead puts an upper bound on the node-degree. In other words, simply covering the area with the minimum number of clusterheads will put more burden on the clusterheads. At the same time, more clusterheads will lead to a computationally expensive system. This may result in good throughput, but the data packets have to go through multiple hops resulting in high latency. As the search for better heuristics for this problem continues, we propose the use of a combined weight metric,that takes into account several system parameters like the ideal node-degree, transmission power, mobility and the battery power of the nodes. They have a fully distributed system where all the nodes share the same responsibility and act as clusterheads [12].

However, more clusterheads result in extra number of hops for a packet when it gets routed from the source to the destination, since the packet has to go via larger number of clusterheads. Thus this solution leads to higher latency, more power consumption and more information processing per node. On the other hand, to maximize the resource utilization, we can choose to have the minimum number of clusterheads to cover the whole geographical area over which the nodes are distributed. The whole area can be split up into zones, the size of which can be determined by the transmission range of the nodes. This can put a lower bound on the number of clusterheads required. Ideally, to reach this lower bound, a uniform distribution of the nodes is necessary over the entire area. Also, the total number of nodes per unit area should be restricted so that the clusterhead in a zone can handle all the nodes in the region. However, the zone based clustering is not a viable solution due to the following reasons [14]. The clusterheads would typically be centrally located in the zone, and if they move, new clusterheads have to be selected. Therefore, to find a new node this can act as a clusterhead with the other nodes within its transmission range might be difficult. Another problem arises due to non-uniform distribution of the nodes over the whole area. If a certain zone becomes densely populated then the clusterhead might not be able to handle all the traffic generated by the nodes because there is an inherent limitation on the number of nodes a clusterhead can handle. As per Anuja Rathee,Yusuf Mulge, We propose to select the minimum number of clusterheads which can support all the nodes in the system satisfying the above constraints[10].

3.3 Cluster-AODV-Based Routing

The AODV protocol sends many packets in comparison to other reactive protocols like DSR. So, when network’s size increases, node degree also increases proportionately, leading to congestion in the network. Clustering reduces this through localized route discovery and maintenance. The suggested Cluster AODV scheme uses clustering architecture and AODV functionalities for routing. This section discusses mechanisms used by Cluster-AODV to lower routing overhead and allows scalability while ensuring good packet delivery ratio.

3.3.1 Intra-cluster routing

Intra-cluster routing is routing within a cluster. Each node has routing information on its cluster. When a node lacks a route to a destination that is in the cluster it sends a Local Route Request (LRREQ). When route failures ensure lack of reply to a RREP, local route maintenance is undertaken within a cluster.

3.3.2 Inter-cluster routing

Inter-cluster routing is routing among clusters. The CH has a 2-hop cluster topology also maintained in a SCH to minimize one point of failure. When routes cannot be found in a cluster once a LRREQ message has been issued, a CH uses a RREQ message to locate a destination via a gateway to 2-hop neighbor clusters. To lower RREQ flooding packet overhead only gateways and CHs forward the RREQ. Ordinary nodes are not involved in RREQ packets in inter-cluster communication.

3.3.3 Route maintenance

Similar to route maintenance, to cluster maintenance starts when a route fails within a cluster and is re-constructed locally using LRREQ and RREQ with 2-hop topology information. When LRREQ fails, an AODV procedure is used and the usual RERR is forwarded to source nodes for route reconstruction. The source node follows the same process to repair failed routes, first locally and then others.

The processes involving a new node which joins and an existing node leaving are carried out based on hello messages from AODV.As per S. Balaji and V. Priyadharsini When CHs exchange neighborhoods information with cluster members, a new node close by can register with a CH by using a RREQ message. When a node goes away from the present CH, it switches its role to that of an ordinary node, a gateway or will be undecided [11]. It will be erased from the old CH and old members’ routing entries are updated accordingly.

4. SIMULATION STUDY

In the proposed work 50 nodes are configured to exchange the information. Each node should identify the neighbours By using WCA the cluster is formed. In the cluster clusterhead (CH) used to exchange the data shown in figure 1,2.

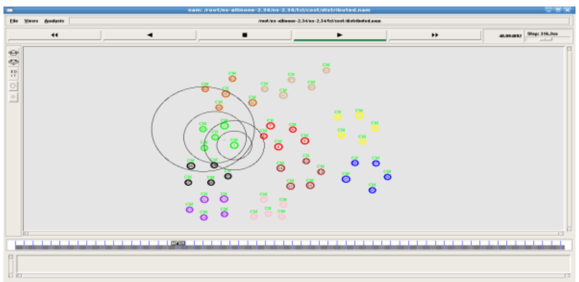

Figure:1 Cluster Formation

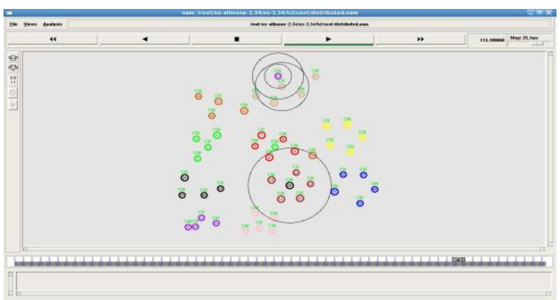

Figure:2 Information Exchange Between The Clusters Using Cluster Head

For number of clusters when transmission range increases, speed also increases. To analyse the performance of the network different speed can be calculated. It is shown in figure 3. To calculate the performance of overhead different speed can be compared is shown in figure4. When speed increases overhead is reduced.

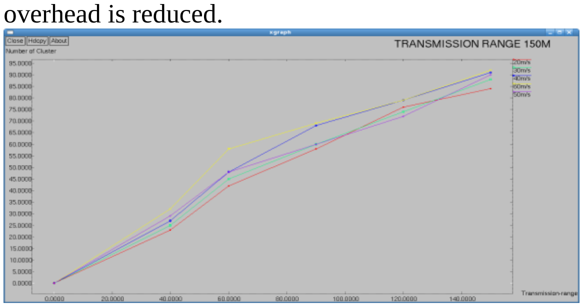

Figure:3 Performance Of Transmission Range

Figure:4 COMPARISION OF 20m/s and 60m/s SPEED

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