A Review on Clustering in MANETs

Deepanshi[*]	**Sonam Dhawan**	**Renu Popli**
Computer Department	*Computer Department*	*DCSA*
GGITC,Ambala,India	*GGITC,Ambala, India*	*KUK, India*

Abstract— Many clustering schemes have been proposed for ad hoc networks. A systematic classification of these clustering schemes enables one to better understand and make improvements. In mobile ad hoc networks, the movement of the network nodes may quickly change the topology resulting in the increase of the overhead message in topology maintenance. Ad-hoc networking is a model in wireless device interactions, which represent that users wanting to communicate with each other form a temporary network, without any form of centralized administration. Each node participating in the network acts both as host and a router and must therefore is willing to forward packets for other nodes. For this purpose, a routing protocol is needed. This means that the routing protocol should try to minimize control traffic, such as periodic update messages. Cluster formation in Ad-hoc network is an important issue; Clustering in Mobile Ad Hoc Networks (MANETs) has many advantages compared to the traditional networks. But the highly dynamic and unstable nature of MANETs makes it difficult for the cluster based routing protocols to divide a mobile network into clusters and determination of cluster heads for each cluster.

Keywords— Load Balancing, Clustering, Routing Protocol, MANETs

I.   INTRODUCTION

Wireless communication between mobile users is becoming more popular than ever before. This has leaded to lower prices and higher data rates, which are the two main reasons why mobile computing continues to enjoy rapid growth. Starting from the development of the packet radio networks (PRNET) in the 1970s and survivable adaptive networks (SURAN) in the 1980s to the global mobile (GloMo) networks in the 1990s and the current mobile ad hoc networks (MANET) [1], the multi-hop ad hoc network has received great amount of research attention. Mobile Ad hoc Network (MANET), set of wireless mobile node forming a temporary network without the aid of any infrastructure or centralized control. Flexibility and Simplicity of adhoc network attracted everyone and solved many problems of communication where infrastructure establishment/reestablishment is not easy task, such as Rescue area, Military operations, creates these components, incorporating the applicable criteria that follow. Modern research area in ad hoc networks has paying attention on MAC and routing strategy. For the reason that of shared wireless broadcast medium, contention, near and for and hidden terminals are common in ad hoc networks and hence MAC demands significant improvement and routing is another issue especially in multi-hop environment. Routing is also an interesting issue as routes are typically multi-hop. An ad-hoc network has certain characteristics, which imposes new demands on the routing protocol. The most important characteristic is the dynamic topology, which is a consequence of node mobility. Nodes can change position quite frequently, which means that we need a routing protocol that quickly adapts to topology changes. The nodes in an ad-hoc network can consist of laptops and personal digital assistants and are often very limited in resources such as CPU capacity, storage capacity, battery power and bandwidth. Instead the routing protocol should be reactive, thus only calculate routes upon receiving a specific request. Generally, traditional routing protocols that are used in wired networks can't support routing in fixed wireless networks and mobile networks with fixed access points. Only one-hop routing is required over a link in a wireless network with fixed access points and many fixed wireless network. Routing in mobile ad hoc networks and some fixed wireless networks use multiple-hop routing. Routing protocols for this kind of wireless network should be able to maintain paths to other nodes and in most cases, must handle changes in paths due to mobility. Traditional routing cannot properly support routing in a MANET. Much wireless technology is based upon the principle of direct point-to-point communication. Popular solutions like Group Standard for Mobile communications (GSM) and Wireless Local Area Network (WLAN) both use an approach where mobile nodes communicate directly with some centralized access point. These types of networks demand centralization for configuration and operation. Contrary to this model is the multi-hop approach. In multi-hop scenarios, nodes can communicate by utilizing other nodes as relays for traffic if the endpoint is out of direct communication range. A mobile ad-hoc network, MANET [2], uses the multi-hop model. These are networks that can be set up randomly and on-demand. They should be self-configuring and all nodes can be mobile resulting in a possibly dynamic network topology.

II.   AD-HOC NETWORKS

Centralized networks, such as GSM, cannot be used in all situations. Significant examples of such scenarios include establishing survivable, efficient, dynamic communication for rescue operations, disaster relief ef¬forts and military networks. Such network scenarios cannot rely on centralized and organized connectivity; they can be conceived as

applications of MANETs. The set of applications for MANETs is diverse, ranging from small, static networks that are constrained by power sources, to large-scale, mobile, highly dynamic networks. To enable multi-hop communication in a distributed manner, all nodes should be able to act as routers for each other (see Figure1). Routes are set up and maintained by a routing protocol. MANET routing protocol design is a complex issue considering the possible rapidly changing topology of such networks. For route maintenance one has two main approaches in MANETs, reactive and proactive. Reactive routing protocols set up traffic routes on-demand, whilst proactive protocols attempts to dynamically maintain a full understanding of the topology. Ad-hoc networks are not restricted to any special hardware. But today such networks are most likely to consist of nodes utilizing so-called WLAN interfaces. These are wireless interfaces operating according to IEEE specifications 802.11a [3], 802.1b [4] or 802.1g [5]. Throughout this document it is assumed that ad-hoc networks consist of links made up by either WLAN or Ethernet [6] interfaces. IEEE 802.11[7] does not support multi-hop communication by itself. Two modes are defined for communication using WLAN devices:

i. Infrastructure mode: The wireless network consists of at least one access point and a set of wireless nodes. This configuration is called a Basic Service Set (BSS). An Extended Service Set (ESS) is a set of two or more BSSs (multiple cells).

ii. Ad hoc mode: This is a peer-to-peer mode. This configuration is called Independent Basic Service Set (IBSS), and is useful for establishing a network where nodes must be able to communicate directly and without any centralized access point.

The Ad-hoc mode is obviously the mode to use when setting up a MANET, but it lacks one basic requirement: multi-hop. Traffic is only transmitted to neighbors within radio range when using the ad-hoc mode, therefore there is a need for MANET routing protocols to set up and maintain traffic paths.

Roberto Carlos Hincapi´e, et al [8] has presented a survey on clustering techniques for MANET. They introduced some preliminary concepts that form the basis for the development of clustering algorithms. They also discussed the related clustering issues with the network topology, routing schemes, graph partitioning and mobility algorithms.

III.   EXISTING ROUTING IN MANET

There, are three types of flat routing strategies exist in MANET. These are reactive, proactive and hybrid [10].

A.   *Proactive Routing Protocols*

Proactive MANET protocols are also called as table-driven protocols and will actively determine the layout of the network. Through a regular exchange of network topology packets between the nodes of the network, at every single node an absolute picture of the network is maintained. There is hence minimal delay in determining the route to be taken. This is especially important for time-critical traffic. When the routing information becomes worthless quickly, there are many short-lived routes that are being determined and not used before they turn invalid. Therefore, another drawback resulting from the increased mobility is the amount of traffic overhead generated when evaluating these unnecessary routes. This is especially altered when the network size increases. The portion of the total control traffic that consists of actual practical data is further decreased. Lastly, if the nodes transmit infrequently, most of the routing information is considered redundant. The nodes, however, continue to expend energy by continually updating these unused entries in their routing tables as mentioned, energy conservation is very important in a MANET system design. Therefore, this excessive expenditure of energy is not desired. Thus, proactive MANET protocols work best in networks that have low node mobility or where the nodes transmit data frequently. Examples of proactive routing protocols are optimized link state routing protocol (OLSR) [11], destination sequenced distance vector routing (DSDV) [12].

B.   *Reactive Routing Protocols*

Portable nodes- Notebooks, palmtops or even mobile phones usually compose wireless ad-hoc networks. This portability also brings a significant issue of mobility. This is a key issue in ad-hoc networks. The mobility of the nodes causes the topology of the network to change constantly. Keeping track of this topology is not an easy task, and too many resources may be consumed in signaling. Reactive routing protocols were intended for these types of environments. These are based on the design that there is no point on trying to have an image of the entire network topology, since it will be constantly changing. Instead, whenever a node needs a route to a given target, it initiates a route discovery process on the fly, for discovering out a pathway.

Reactive protocols start to set up routes on-demand. The routing protocol will try to establish such a route, whenever any node wants to initiate communication with another node to which it has no route. This kind of protocols is usually based on flooding the network with Route Request (RREQ) and Route reply (RERP) messages. By the help of Route request message the route is discovered from source to target node; and as the target node gets a RREQ message it send RERP message for the confirmation that the route has been established. This kind of protocol is usually very effective on single-rate networks. It usually minimizes the number of hops of the selected path. However, on multi-rate networks, the number of hops is not as important as the throughput that can be obtained on a given path. Examples of reactive routing protocols are ad-hoc on demand distance vector (AODV)[13], Dynamic source routing(DSR)[14].

C. Hybrid Routing Protocols

Since proactive and reactive protocols each work best in oppositely different scenarios, hybrid method uses both. It is used to find a balance between both protocols. Proactive operations are restricted to small domain, whereas, reactive protocols are used for locating nodes outside those domains.

Both methods explained before, only demonstrate good performance under certain conditions. But what if a balance point between proactive and reactive routing is found by adjusting the degree to which route information is propagated proactively versus the degree to which it needs to be discovered reactively? If we combine the advantages of both techniques obtaining as a result a particular routing protocol which is able to adapt himself to the behavior of the network.

By a Hybrid routing protocol the following characteristics must be present:

i.   Adaptive: should be applicable to wide range of network characteristics. Node mobility, traffic patterns should be handled easily.

ii.   Flexible: should enable the optimization. Applications should be able to be adapted to the different application-specific metrics at the routing layer .These goals should be set by the network participants

iii. Efficient and Practical: The protocol should achieve better performance than pure, non-hybrid, strategies without invoking costly low-level primitives. Such as reliable broadcasts and distributed agreements Hybrid protocols try to explode the benefits of both Proactive and Reactive protocols.

The proactive part of the protocol is reduced to a small neighborhood of a node. The network is divided in small networks in order to decrease the problem of delay.

The reactive part is used for routing across the network. Routing in large scale networks is implemented to reduce the overhead control problem.

The main difference between the Hybrid Adaptive protocols is the way they implement the PRP and RRP, and the way they define the routing zones. Next, we will briefly describe the most known Hybrid protocol, to finally compare them with each other Example of hybrid protocols are zone routing protocol (ZRP)[15], cluster based routing protocol(CBRP)[16]. The evaluation predicts that in spite of slightly more overhead in some cases DSR and AODV in all cases. AODV is still better in Route updating and maintenance process.

IV.   CLUSTERING IN MANET

Grouping sensor nodes into clusters has been widely pursued by the research community in order to achieve the network scalability objective. Every cluster would have a leader; often referred to as the cluster-head (CH). A CH maybe elected by the sensors in a cluster or pre-assigned by the network designer. A CH may also be just one of the sensors or anode that is richer in resources. The cluster membership may be fixed or variable. CHs may form a second tier network or may just ship the data to interested parties, e.g. a base station or a command centre. Here, Fig 1 explains the traditional station scheme of Clustering using ad-hoc multi-hop network.
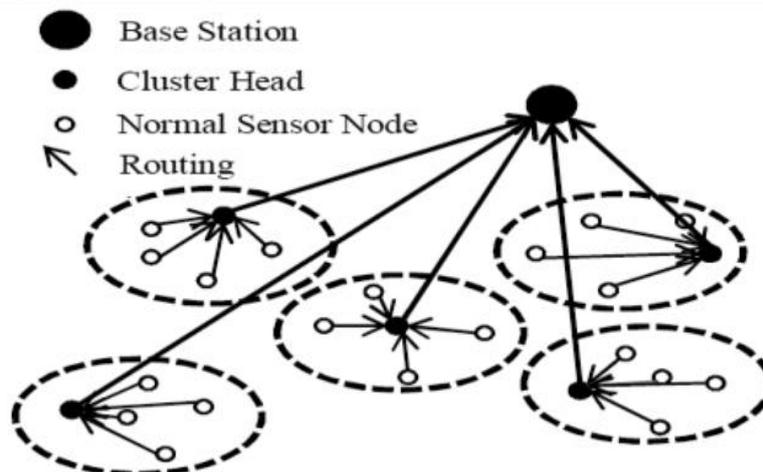

Fig 1: A traditional station scheme of Clustering using ad-hoc multi-hop network.

Here are some Clustering Goals:
➢ Achieve communication scalability for a large number of nodes and high mobility.
➢ Spatial reuse and coordination of resources.
  •   Increase system capacity.
  •   Reduce retransmissions and collisions.
  •   Balance the use of resources in the network.
➢ Virtual communication backbone.
➢ Inter-cluster communication can be restricted to cluster-heads and cluster-gateways.
➢ Local changes.
➢ Update and maintain cluster information only locally.
➢ Minimize information stored and propagated in the network.

Advantages of clustering are:
➢ Reusability: spatial reuse of resources at nodes.
➢ Simplification: of addressing.
➢ Stability and Localization: smaller and potentially mode stabile sub-networks structures.

Disadvantages of clustering are:
➢ Explicit control messaging: clustering related information exchange.
➢ Ripple effect: rebuild of cluster structure in case of network structure changes.
➢ Stationary period: collect and exchange information for cluster formation.
➢ Computation rounds: number of rounds to complete the cluster election.
➢ Communication complexity: amount of control messages exchanged.
➢ No common solution.

Cluster Based Routing In MANETs :

1. Location Based Clustering

In the location-based routing protocol, the location information of mobile nodes are used to confine routing space into a smaller range .It reduces routing overhead and broadcast storm. [17]. In [17] Tzay-Farn Shih and Hsu Chun Yen have proposed a cluster-based routing protocol, named Core Location-Aided Cluster-based Routing protocol (CLACR). The characteristics of CLACR are stated as the entire network is partitioned into square clusters. In each cluster, the selection of cluster head is done by a cluster head election algorithm. The number of nodes responsible for routing and data transfer is decreased considerably by the usage of the cluster mechanism. It also diminished the routing overhead and increased the route lifetime massively. The path is computed using Dijkstra algorithm in a cluster-by-cluster basis by the CLACR.

2. Mobility Based Clustering

In [18] S. Muthuramalingam et al proposed a modified algorithm that uses Weighted Clustering Algorithm (WCA) for cluster formation and Mobility Prediction for cluster maintenance. In a MANET node management is done by Clustering. Cluster formation: At first, a beacon message is send by each node to notify its presence to its neighbors. A beacon message contains the state of the node. A neighbor list is built by each node based on the received beacon messages. The cluster head is elected based on the weight values of the nodes. The node with the lowest weight is chosen as the CH. Maintenance: It has two distinct types of operations like the battery power threshold property and the node movement to the outside of its cluster boundary. Mobility prediction: The improvement in the weighted clustering algorithm is due to the use of mobility prediction in the cluster maintenance phase.

3. Neighbor Based Clustering

In [19] Hui -Yao An et al proposed a Cluster-Based Multipath Dynamic Source Routing in MANET (CMDSR). In this scheme, the hierarchy is used to perform Route Discovery and distributes traffic among diverse multiple paths.
Cluster Architecture: The CMDSR is based on the 3-level hierarchical scheme. The 0-node is the first level of the cluster. 1-cell cluster is the second level of cluster. Here each node of the cell is 1-hop away from the Cluster Head. The 2-server cluster gathers a set of cells of which the Server is the leader. The cluster changes due to the nodal mobility dynamically. Hence the cluster will be disassembled or reassembled and also the cluster members update at every turn.

4. Power Based Clustering

In [20] Pi-RongSheu and Chia-Wei Wang proposed an efficient clustering algorithm that can establish a stable clustering architecture by keeping a host with weak battery power from being elected as a cluster head. In their proposed new clustering algorithm, a stable clustering architecture is formed by defining a bottleneck node to be a node with battery power lower than a predefined value Threshold. Bottleneck cluster head refers to the bottleneck node elected as a cluster head. The proposed clustering algorithm is based on the assumption that if the clustering architecture has fewer bottlenecks then the cluster heads have a longer lifetime.

5. Artificial Intelligence Based Clustering

In [21] Chongdeuk Lee and TaegwonJeong proposed a Fuzzy Relevance-based Cluster head selection Algorithm (FRCA). The proposed mechanism selects the cluster head using fuzzy relevance for clustering in wireless mobile ad hoc sensor networks. In the network, the Fuzzy Relevance-based Cluster head selection Algorithm (FRCA) efficiently clusters and manages sensors using the fuzzy information of node status. The Fuzzy Relevance Degree (FRD) with fuzzy value μ is used to perform and manage clustering in the proposed FRCA. In the proposed algorithm, some nodes acting as coordinators of the clustering are chosen by FRD to perform clustering.

6. Weighed Based Clustering

In [22] R. PandiSelvam and V.Palanisamy presented a flexible weight based clustering algorithm in mobile ad hoc networks. The proposed algorithm is a 2-hop clustering algorithm. The performance of the proposed clustering algorithm showed that it outperformed the existing LID, HD and WCA to make the number of clusters. It also increases the number of nodes, transmission range and maximum displacement. The weight of each node is calculated by the weight function

w(p). The cluster head election is done by comparing the weight of each node with its neighbors in the two hop range. The node with highest weight declares itself as the cluster head.

V. CONCLUSION

In this survey paper, an effort has been made to concentrate on the comparative study and performance analysis of various on demand or reactive routing protocols (DSR, AODV and TORA) on the basis of above mentioned performance metrics and gives detailed comparison of various clustering techniques for MANET. It has been observed that the performance of all protocols studied was almost stable in sparse medium with low traffic. TORA performs much better in packet delivery owing to selection of better routes using acyclic graph. The results indicate that AODV keeps on improving with denser mediums and at faster speeds. This paper also discussion of weight based approach in the previous section, we can conclude that the weight based clustering approach is the mostly used technique for cluster head selection and the common parameters for weight estimation include node degree, transmission power, mobility, distance and residual battery power. In some cases, stability and connectivity are also taken into account. So we need an artificial intelligence technique like Fuzzy logic or PSO to select the appropriate weight parameters for cluster head thereby minimizing the overhead and maximizing the throughput.

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