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Survey of Routing Scheme in MANET with Clustering Techniques

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ABSTRACT: *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. In recent years, several routing protocols and Cluster based protocols have been proposed for mobile ad hoc networks and prominent among them are DSR, AODV. This survey paper provides an overview of these protocols by presenting their characteristics, functionality, benefits and limitations and then makes their comparative analysis so to analyze their performance and compare some of existing works on clustering in MANETs. We categorize the works as Location based, Neighbor based, Power Based, Artificial Intelligence Based, Mobility based and Weight Based. We also present the advantages and disadvantages of these techniques and suggest a best clustering approach based on the observation. The objective is to make observations about how the performance of these protocols can be improved.*

Keywords**:** *MANET; Routing Protocol; Clustering; AODV; CMDSR.*

I. INTRODUCTION

Wireless communication between mobile users is becoming more popular than ever before. This due to recent technological advances in laptop computers and wireless data communication devices, such as wireless modems and wireless LANs. 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.

1.1 Ad-hoc network*s*

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.

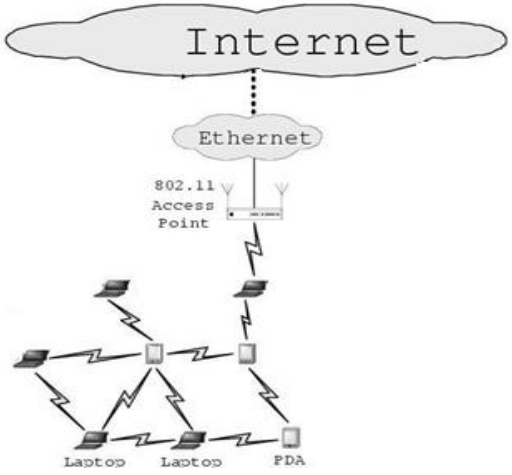
For route maintenance one has two main approaches in MANETs, reactive and proactive. Reactive routing protocols set up traffic routes on-demand, whilst proactive protocols attempts to dynamically maintain a full understanding of the topology.

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:

- Infrastructure mode: The wireless network consist 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).
- 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.

a) Usig Base Station



b) Mobile Ad-hoc network

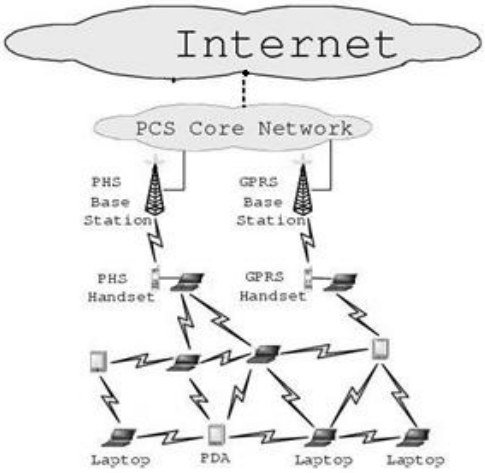


Fig 1: A traditional station scheme compared to an ad-hoc multi-hop network.

II. RELATED WORK

In this section we present some of existing works on survey of clustering in MANETs and Routing protocols. 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. They also described some of the most popular clustering techniques like Lowest-ID heuristic, Highest degree heuristic, DMAC (distributed mobility-adaptive clustering), WCA (weighted clustering algorithm).They also reviewed several clustering algorithms to organize mobile ad hoc networks in a hierarchical manner and explained their advantages and disadvantages.

Ratish Agarwal and Dr. Mahesh Motwani [9] have reviewed several clustering algorithms to organize mobile ad hoc networks in a hierarchical manner and presented their main characteristics. The survey examined the important issues related to cluster-based MANET, such as the cluster structure stability, the control overhead of cluster construction and maintenance, the energy consumption of mobile nodes with different cluster-related status, the traffic load distribution in clusters, and the fairness of serving as cluster heads for a mobile node.

III. EXISTING ROUTING IN MANET

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

3.1 Proactive Routing

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].

3.2 Reactive 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].

3.3 Hybrid Routing

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

Parameter	AODV	DSR	DSDV	OLSR	ZRP	CBRP
Control message	3 types-RREQ,RREP,RERR	3types-RREQ,RREP,RERR	2 type-HELLO & Update	2 type- HELLO and TC	Hello, Update, for inter zone-RREQ,RREP	HELLO ,RREQ,RREP,RERR
Central Administration	NO	NO	NO	NO	node	Cluster head
Route discover	Each source node broadcast RREQ on demand	Each source node broadcast RREQ on demand	Already have info for all destination	Already have info for all destination	For intra zone have info , but for inter zone broadcast RREQ	For intra cluster have info , but for inter zone broadcast RREQ
Loop free routing	Yes, Due to sequence no.	Yes , due to address in packet header	Yes, due to sequence no.	Yes, due to sequence no.	Yes.	Yes.
Type of routing	Hop by hop	Source routing	Hop by hop	Hop by hop	Hop by hop	Hop by hop, but for inter zone source routing
Link support	Symmetric	Symmetric	Symmetric	Link to MPR-Symmetric, rest can be anything	Symmetric	Supports both Symmetric, Asymmetric
How path is build	By keeping backward pointer and forwards RREQ	Intermediate node insert its address in packer	Next hop is calculated by neighbors routing table	Next hop is calculated by neighbors routing table	Intra zone by routing table, inter zone on demand	Intra cluster by routing table, inter zone on demand
Scalable	Yes but vulnerable to network change	No	No	No	Yes	No
Protocol type	Reactive	Reactive	Proactive	Proactive	Hybrid	Hybrid
Metric	Shortest path	Shortest path	Shortest path	Cost	Shortest path	Shortest path

Advantage	At higher load incur lower delay; Unicast, multicast and broadcast communication possible.	Better in terms of collision; Doesn't flood network with updates; Routes maintained only when communication is done; Single route discovery may result multiple route to same destination	In small network size delay is smallest and throughput is high; Guarantees loop free	Limited broadcasting due to MPR; Being proactive routes to all destination available; Useful in application where less route discovery delay required	It tries to maintain most up to date map of network; Requires less bandwidth ; Mobility of cluster head	Use of clustering to minimize on demand route discovery; Link break locally repaired; Mobility of cluster head
Disadvantage	Collision is high; Route discovery latency in high scale network; Lack of efficient maintenance technique	Access delay increases and throughput decrease as increase in network size; Route maintenance mechanism doesn't locally repair broken link ; Route cache may stale; Connection set up delay is high; As network grows packet header size grows.	Higher delays for large network; Wastage of bandwidth due to unnecessary updates even if no change; Difficult to determine time delay for advertisement	Due to periodic update bandwidth is wasted; Maintains route most of which never used	Latency for finding new routes; If node not in any zone cannot communicate	Due to source routing , if network size grows packet size increases; Useful in small cluster only

Table 1. The evaluation of DSR, AODV, DSDV, OLSR, ZRP and CBRP in all case.

protocol which is able to adapt himself to the behavior of the network. By a Hybrid routing protocol the following characteristics must be present

- Adaptive: should be applicable to wide range of network characteristics. Node mobility, traffic patterns should be handled easily.
- 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
- 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]. Table 1 is description of other important parameters that make a protocol robust and steady in most cases. 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. CLUSTER BASED ROUTING IN MANETS

4.1 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.

4.2 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.

4.3 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.

4.4 Power Based Clustering

In [20] Pi-Rong Sheu 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.

4.5 Artificial Intelligence Based Clustering

In [21] Chongdeuk Lee and Taegwon Jeong 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.

4.6 Weighed Based Clustering

In [22] R. Pandi Selvam 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. Table 2 shows the comparison of different clustering techniques at a glance.

Table 2. The evaluation of DSR, AODV, DSDV, OLSR, ZRP and CBRP in all cases.

S. No:	Name of protocol	Type	Advantages	Performance metrics	Over head
1.	Core Location-Aided Cluster-Based Routing Protocol for Mobile Ad Hoc Networks[17]	Location based	i) Route life time increases. ii) Collision probability reduced. iii) Broadcast storm problem diminished.	Route construction success ratio, Route set up time, Route life time, Data delivery rate.	yes
2	A Dynamic Clustering Algorithm for MANETs by modifying Weighted Clustering Algorithm with Mobility Prediction[18]	Mobility based	i) Reduce the Power Consumption. ii) Reduces the bandwidth wastage for signals other Than Data. iii) Increase the Stability Of the Cluster.	Minimum life span of nodes, Stability of the Cluster, Throughput, Control overhead, Packet delivery Ratio, Connectivity.	yes
3	A Cluster-Based Multipath Dynamic Source Routing in MANET[19]	Neighbor based	i) improves scalability, ii) Prevents the network flooding, iii) overhead is minimized, iv) Higher and more consistent success delivery ratio. v) Lower error ratio.	average end-to-end delay, Received packets, Success delivery ratio, Error delivery ratio, control overhead.	Yes
4	A Stable Clustering Algorithm Based on Battery Power for Mobile Ad Hoc Networks[20]	Power based	i) better performance, ii) higher stability,	Clustering architecture life time, Minimum battery power, Network lifetime.	No
5	FRCA: A Fuzzy Relevance-Based Cluster Head Selection Algorithm for Wireless Mobile Ad-Hoc Sensor Networks[21]	Artificial intelligence based	i) reduces the overhead ii) Efficient management of node positions and energy. iii) Improvement of routing performance.	Number of clusters, Overhead rate, Cluster head selection rate,	Yes
6	Stable and Flexible Weight based Clustering Algorithm in Mobile Ad hoc Networks[22]	Weighted clustering based	i) stable and flexible against topology changes ii) Increase the number of nodes, transmission range And maximum displacement.	transmission ranges, number of nodes and Maximum displacement.	No

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. The results after analysis have reflected in Table I. The first table is description of parameters selected with respect to low mobility and lower traffic. 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. Table I is evaluation of same parameters with increasing speed and providing more nodes. 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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