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Routing and Broadcasting in MANET: A comprehensive Analysis based on, Routing technique, Clustering and Architectural Model

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Abstract

A Mobile Ad-hoc Network (MANET) is a temporary and infrastructure less dynamic network in which all nodes are mobiles and they communicate with each other via wireless connections. There is no central control and this network demands new networking strategies because of the topology of this network is regularly changing due to the frequent mobility of nodes. MANET is using the TCP/IP traditional structure and needs redefinition or alterations in each layer because of the limited resource and mobility. In MANET, routing is a challenging task and it requires the development of different routing protocol, new dynamic and routing techniques. This paper provides an overview and analysis of various basic routing techniques, strategies, clustering, MANET architectures and protocols. Further, this work specifically studies and analysis the unicast, multicast, broad cast, link state and distance-vector routing protocols and also discusses the cluster based routing techniques. The link-state or distance-vector routing technique is used in the topology based protocols. Link state routing is better for large network because of fast convergence, loop less convergence and support of multiple metrics. So the link state routing is better than the distance vector routing.

Keywords: Ad hoc, Routing, Clustering

Introduction

A Mobile Ad-hoc Network (MANET) is a temporary wireless network without having fixed infrastructure to interact and its aims to processing synchronized data transformation, and assured data transaction.

MANET can find its applications in the following areas [17]

Military use, intelligent transportation in Vehicle-to-vehicle communication [5], Search and rescue. Ad hoc networks in airports, meeting, natural disaster, PAN (Personal Area Networks) connecting mobile phones, laptops systems, smart watches, and other computers,

Traditional routing protocols used in hardwired networks, such as distance vector protocols and link state protocols cannot be applied in the MANET directly for the following reasons: There may be uni-directional links between nodes. There is more than one eligible path between two nodes

The consumption of bandwidth and power supply incurred by periodic routing information updates is considerable

The routing fabrics converge slowly in contrast to rapid topology change.

Most research effort has been put in the routing protocols since the advent of the MANET. They can be divided into the following categories [17] [35] [7]
  (1) Unicast routing protocols
  (i) Topology-based routing protocols
   Proactive routing protocols
   Reactive routing protocols
   Hybrid routing protocols
  (ii) Geographical-based routing protocols
  (2) Multicast routing protocols
  (3) Broadcast algorithms

Routing is the process of conveying information from a source node to a destination node. Host routing and router routing are the two important processes in routing mechanism. When the host route forwards a packet to another host node is called host routing.

The sending host decides whether to forward the packet to the destination node or to a router based on the target network address.

Unicast routing

In this type of routing, the source node delivers individual copy to all receiver nodes. So, packets are duplicated in the source node and sends to each destination in the MANET. Most proposals in the MANET are based upon unicast communication. Thus, the most basic operation in the MANET IP layer is to effectively convey data packets from one source node to another destination node. The forwarding method is very humble in itself: with the routing table, the transmit node just uses the endpoint address in the data packet to look it up in the routing table. If the longest matching destination address is found in the table, the packet is sent to the corresponding next hop. The problem that arises is how the routing table is built in the nodes in the MANET [17] [2] [33].
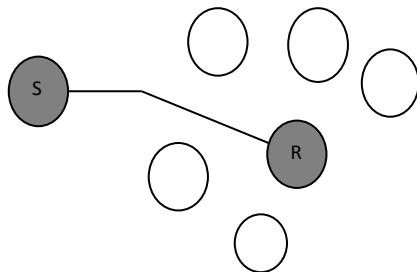
a. Topology based Unicast
b. Geographical based Unicast

Figure:1 Uni-cast Routing

A. *Proactive topology based- unicast routing protocols [7]*

Optimized Link State Routing Protocol (OLSR), Fisheye State Routing Protocol (FSR), Topology Broadcast Based on Reverse-Path Forwarding Routing Protocol (TBRPF), Dynamic Sequenced Distance Vector Routing Protocol (DSDV), Cluster Gateway Switch Routing Protocol (CGSR), Global State Routing Protocol (GSR), Hierarchal State Routing Protocol (HSR),Zone Based Hierarchal Link State Routing Protocol (ZHLS).

B. *Destination Sequenced Distance-Vector Routing Protocol*

(DSDV): Routing table in DSDV needs regular updating. And it is suitable for creating small ad hoc network. It was developed by C. Perkins and P. Bhagwat in 1994 [28] [32].

D.Loganathan, P.Ramamoorthy describes [34] the DSDV routing develops a new attribute, sequence number, to all route table entry; the data packet exchange will increase each time network topology change. The author developed the Multi cost Parameters Based DSDV protocol outclasses is better because of it has adjustable transmission power in high mobility so as to enhance the network energy and network lifetime also allowing the max/min Energy-Half-Interference-Half Hop algorithm [34].

C. *Reactive topology based- unicast routing protocols*

Dynamic Source Routing Protocol (DSR), Ad hoc On-Demand Distance Vector Routing Protocol (AODV) [36], Associatively Based Routing Protocol (ABR), Signal Stability based Adaptive Routing Protocol (SSA), Temporarily Ordered Routing Protocol (TORA), Cluster based Routing Protocol (CBRP).

D. *Hybrid topology based- unicast routing protocols*

Zone Routing Protocol (ZRP), Adaptive Distance Vector Routing Protocol (ADV),Dual Hybrid Adaptive Routing Protocol (DHAR)

Geographical-based unicast routing protocols: Location-aided routing (LAR), Geographical Routing Algorithm (GRA).

Location service for Geographical-based routing protocol: DREAM system, Quorum system, Grid system, home agent-based system Proactive, reactive, and hybrid routing protocols are summarized and compared in table1. [17][4].

Table.1 Summary Of Proactive, Reactive And Hybrid Routing Protocols

	Proactive	**Reactive**	**Hybrid**
Network organization	Flat / Hierarchical	Flat	Hierarchical
Topology Dissemination	Periodical	On-demand	Both
Route latency	Always available	Available when needed	Both
Mobility Handling	Periodical updates	Route maintenance	Both
Communication Overhead	High	Low	Medium

Multicast routing

The source delivers a same packet to multiple receivers in the network at the same time; this method is called packets broadcast. [2]
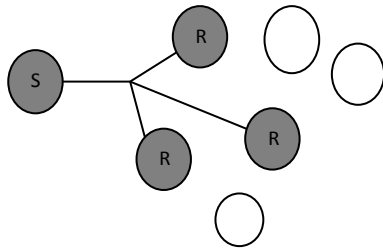

Figure:2 Multicast Routing

A. Tree-based multicast routing

There is single pathway among a source node and receiver node in tree-based multicast protocols. But in the high mobility position, the tree based protocol is not enough to handle the tough environment. Two routing methods in multicast routing (i) Source-tree-based multicast routing, (ii) Shared-tree-based multicast routings. Single tree is maintained in source tree based, a single tree is shared by all source node is called shared tree method and its scalable [6]. Some multicast protocols are Ad Hoc Multicast Routing(AMRoute), Ad Hoc Multicast Routing Protocol Using Increasing Id-numbers (AMRIS), Multicast Operation of Ad Hoc On-demand Distance Vector (MAODV) [37].

B. Mesh-based multicast routing

In multicast routing, multiple paths between the source and destination nodes and using multiple hop. The link between the nodes breaks because of nodes are geographically moving (mobility) and using multiple hops. Some multicast protocols are On-demand Multicast Routing protocol (ODMRP), Core-Assisted Mesh Protocol (CAMP) [37].

Broadcast routing

In this system, all therecipients getting message simultaneously.ex: Multipoint Relaying, Scalable Broadcast Algorithm.
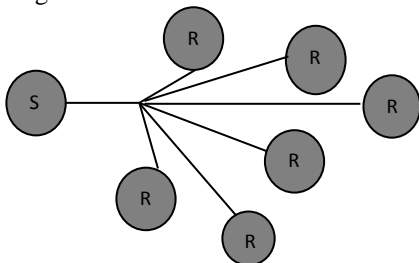

Figure: 3 Broadcast Routing

Routing techniques

1. Link state Routing
2. Distance Vector Routing
C. Link state routing

The flooding strategy method is used in link-state routing to update the status of neighbouring node to periodically broadcasting its status. To applying a shortest-path algorithm to desire the next hop node for each target when each node getting an update packet and also updating the routing table to obtains a MANET view[1].

Link state routing algorithm

In this routing algorithm all the nodes in the network broadcast message regarding the cost of reaching its neighbour to all nodes. Instead of sending whole table to other node, it's only sending part of the table. OSPF, IS-IS and EIGRP are routing protocol using the link state routing algorithm [9] [29].
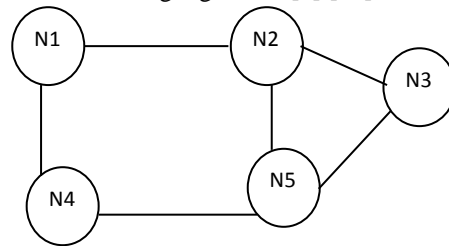

Figure:4 Link state Routing

Table.2 Link state routing table

Link State routingprocess

NODES	LINK BETWEEN NODE	COST
N1->N2	N1N2	1
N1->N4	N1N4	1
N2->N1	N2N1	1
N2->N3	N2N3	1
N2->N5	N2N5	1
N3->N2	N3N2	1
N3->N5	N3N5	1
N4->N1	N4N1	1
N4->N5	N4N5	1
N5->N2	N5N2	1
N5->N3	N5N3	1
N5->N4	N5N4	1

These protocol consist three different tables: a topology table, a neighbor table, and an actual routing table. Find out its neighbors and construct its neighbor table and calculate the cost of its neighbors (delay, bandwidth, etc).Construct and send a routing update to make the shortest path to all possible target nodes by using the Dijkstra algorithm. The process is

given below: **Process1:** Neighbour Detection:The router periodically sends a HELLO message on each of its links. Neighbor routers respond to these HELLO messages recognize themselves. **Process2:** Calculate Link Cost **Process3**: Construct and Allocate Link State Packet

A. Distance-vector routing

Distance-vector routing protocols uses the Bellman–Ford algorithm, Ford–Fulkerson algorithm, or DUAL FSM to calculate paths.In**,** for every destination t, each node n maintains a set of distances D_{nj}^t where j ranges over the neighbours of node n. Node n selects a neighbour, k, to be the next hop for **x** if $D_{nk}^t = \min_j \{D_{nj}^t\}$. This allows each node to select the shortest path to each destination. The distance-vector information is updated at each node by a periodical dissemination of the current estimate of the shortest distance to every node. [1]The traditional link-state and distance-vector algorithm do not scale in large MANETs. To overcome the problems associated with the link-state and distance-vector algorithms a number of routing protocols have been proposed for MANETs. These protocols can be classified into three different groups: global/proactive, on demand/ reactive and hybrid. [1]

The entire routing table has sent to its neighbour node in the network. Some of the distance vector routing protocols are RIP (Routing Information Protocol), IGRP (Interior Gateway Routing Protocol) [9].

Table.3 Summary Of Multicast Routing

| Multicast Protocols	Multicast Topology	Initialization	Independent of Routing Protocol	Dependency on Specific Routing Protocol	Maintenance Approach	Loop Free	Flooding of Control Packets	Periodic Control Messaging
ABAM	Source-tree	Source	Yes	No	Hard state	Yes	Yes	No
BEMRP	Source-tree	Receiver	Yes	No	Hard state	Yes	Yes	No
DDM	Source-tree	Receiver	No	No	Soft state	Yes	Yes	Yes
MCEDAR	Source-tree over Mesh	Source or Receiver	No	Yes (cedar)	Hard state	Yes	Yes	No
MZRP	Source-tree	Source	Yes	No	Hard state	Yes	Yes	Yes
WBM	Source-tree	Receiver	Yes	No	Hard state	Yes	Yes	No
PLBM	Source-tree	Receiver	Yes	No	Hard state	Yes	No	Yes
MAODV	Shared-tree	Receiver	Yes	No	Hard state	Yes	Yes	Yes
Adaptive Shared	Combination of Shared-and Source-trees	Receiver	Yes	No	Soft state	Yes	Yes	Yes
AMRIS	Shared-tree	Source	Yes	No	Hard state	Yes	Yes	Yes
AMRoute	Shared-tree over Mesh	Source or Receiver	No	No	Hard state	No	Yes	Yes

Courtesy: http://my.safaribooksonline.com
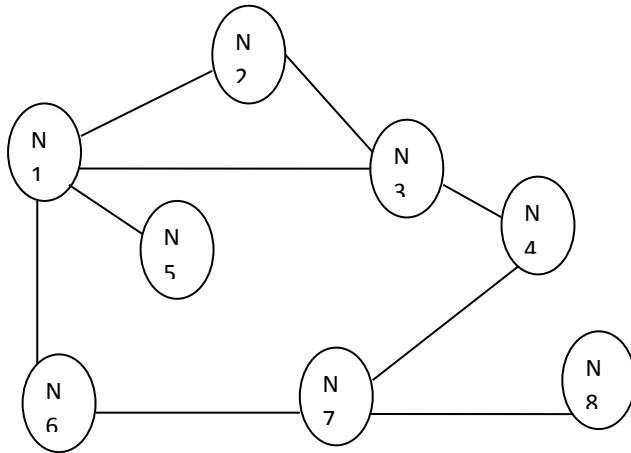
Figure:5 Each node in the network knows the cost of the link to each of its straightly attached neighboring node.

Table .4 Distances Between Each Node

NODE	DISTANCE TO REACH NODE							
	N1	N2	N3	N4	N5	N6	N7	N8
N1	0	1	1	-	1	1	-	-
N2	1	0	1	-	-	-	-	-
N3	1	1	0	1	-	-	-	-
N4	-	-	1	0	-	-	1	-
N5	1	-	-	-	0	-	-	-
N6	1	-	-	-	-	0	1	-
N7	-	-	-	1	-	1	0	1
N8	-	-	-	-	-	-	1	0

Table 1 represent each node's knows about the distances to all other nodes .Note that each node only knows the information in one row of the table. Each node in the network sends a message to its neighboring node directly. (For example node N1 sends message to its neighbor nodes N2, N3, N5, and N6).After every node has swapped a few messages with it's straightly coupled neighbors, all nodes will identify the least-cost path to all the other nodes. In accumulation to fill in their record of distances when they obtain updates, the nodes need to maintain pathway of which node told them about the path that they used to compute the cost, so that they can generate their forwarding table. For example, **N2** knows that it was **N1** who said "I can reach **N5** in one hop" and so **N2** puts a right of entry in its table that says "To arrive at **N5**, apply the connection to **N1**.)[9]

The above table 6 describes the full routing details of node N2.The highest cost of node is N8. The lowest cost nodes are N1 and N3. Distance between the two nodes are calculated by using this hop count and also it is used to find slip in a network Next closest node can be termed as next hop.

Table. 5 complete distances stored at each node

NODE	DISTANCE BETWEEN NODES							
	N1	N2	N3	N4	N5	N6	N7	N8
N1	0	1	1	2	1	1	2	3
N2	1	0	1	2	2	2	3	4
N3	1	1	0	1	2	2	2	3
N4	2	2	1	0	3	2	1	2
N5	1	2	2	3	0	2	3	4
N6	1	2	2	2	2	0	1	2
N7	2	3	2	1	3	1	0	1
N8	3	4	3	2	4	2	1	0

Table.6 Complete Routing Tables Keep In N2

DESTINATION	COST	NEXT HOP
N1	1	N1
N3	1	N3
N4	2	N3
N5	2	N1
N6	2	N1
N7	3	N1
N8	4	N3

Cluster based routing techniques
Position-Based Prioritized Clustering Technique
Cluster is a technique used to grouping related entities. In MANET, related nodes are logically grouped together and it can be shorten such necessary functions as routing, channel access and bandwidth allocation. In the network, cluster head has been elect by using some empirical clustering methods such as lowest ID, highest degree, and node-weight heuristics. [11][10]

Cluster Head Election Algorithm
Three approaches are used for cluster head selection. The first one is message packets posted in network travel locally. Second, based on the definition of MDS (minimal dominating Set), the cluster head

selection information for any node should comprise only nodes that are one step or two steps further than the node itself, since every node is one hop away from a cluster head. The last one is, too many cluster heads around the same set of nodes operate to no MDS [12]. Another one approach is granted priority algorithm (SCSA). The priority can be identified by the following aspect: Network model, Cluster lifetime, Cluster head election process [27].

Cluster head election
In the opening stage of establishing cluster, the nodes are allotted as the role of gateway, cluster head and cluster member in the cluster using the clustering formula.

Hello messages are broadcast by each node periodically to establish the connectivity.

[12] Uses the algorithm to bring the weight information in Hello message, once the node get the Hello message, it updates the related nodes' standing value. The node can also obtain and update its mobility, transmission power and degree based on the number of messages received. The node gets its initial weight after getting the Hello message in some period then broadcasts its weight. After publishes its weight and compared then the highest weight node is elected as head of cluster [8].

If the node A obtains the cluster head information from its neighbour node B, and node B's standing value is higher than A's, A will send the message to node B to link in its cluster. If node A hasn't acknowledged the cluster head's information during a period, it becomes an isolate cluster head which has no cluster member. [12][18]

K.Ramesh and Dr. K.Somasundaram [30] describes different clustering systems are classified and analysis with unique importance on their cluster head selection policy. The schemes are compared with respect to their requirement of (1) clustering during each round for selecting the cluster heads, (2) cluster formation required after each rotation of role of cluster head, (3) distribution of cluster heads over the network, (4) relation of balanced clusters, (5) parameters used and (6) the assistance considered to highlight the effect of cluster head selection strategy on the performance of these schemes.

SrieVidhyaJanani. E yet.al [31] describes in the Cluster Head Selection in WSN, to maximize the network life time optimal cluster head selection is important. To obtain optimal cluster head, CH should be elected based on the residual energy of each and every node. Therefore energy efficiency is maximized & network lifetime is also prolonged.

The distributed clustering algorithm Basagni proposed two algorithms, namely distributed clustering algorithm (DCA) and distributed mobility adaptive clustering algorithm (DMAC). In these two tactics, based on the suitability, each node is assigned a weight to obtain the head. The node weight is compared with its neighbour node and the highest weighted node can be elected as head other nodes are joins as neighbouring in the cluster group. [13][19]

The Weighted Clustering Algorithm
SAJAL and TURGUT proposed WCA algorithm. It pays collective metrics-based clustering: the Degree difference, sum of the distance with all neighbours, average of the speed, total time, are taken into account to calculate a weight factor WV for every node.

The weight of its neighbour node can be checks by each node and Select V with the minimum WV as the cluster head [13] [20] [35].
The Highest-Degree Algorithm

This algorithm was proposed by Gerla and Parekh, consider n1 and n2 are neighbouring nodes if n1 takes within the transmission range of n2. Every single node broadcasts its id to all nodes in the network that located in the transmission range. The highest Degree node (Maximum number of neighbours) is elected as cluster head and other neighbouring nodes in the network are treated as cluster member. [13][21]
The Lowest-ID Algorithm

This Algorithm was proposed by Baker and Ephremides. It allots a separate id for each node. A node with minimum id is elected as a cluster head. Hence the id of the cluster head neighbours should be more than cluster head's id. [13][21]

Cluster head Election using Fuzzy Logic
K. VenkataSubbaiah[26] presents a fuzzy logic system cluster head election scheme using (FLS) for mobile ad hoc networks. Distance *of* a node to the cluster centroid, its remaining battery capacity, and its degree of mobility, the above three descriptors are used. The linguistic knowledge of cluster head election based on these three descriptors is obtained from a group of network experts [26].

MANET architectural model
MANET node morphology

This Morphology architectural model express MANET node as routers with hosts committed. This denotes that, connectivity is via a classic IP link from the point of view of the hosts, and the applications running on these hosts. Hosts, and its applications, are not visible to the specific characteristics of the MANET interfaces and are linked to the MANET via a router, which has one or more MANET interfaces. The prefix P can be allotted to the classic IP link(s) when the MANET router is delegated, and hosts can be assigned addresses from within this prefix, and configured with this prefix. [14]

Nested Mobile Networks
The collection of mobile router can attached with one another or to any other router to forming networks of mobile routers to random depth, and these mobile routers may detach or alteration their socket at any given time. This environment is termed as nested mobile network. [14][22]

Architecture for Directional Antennas
The advantages of the Directional antennas are spatial potential reuse; provide longer transmission and reception ranges for the same amount of power. In MANET, when comparing Directional antennas with omi-directional antennas, its gives some rewards like above. At the same time, to implement the directional antenna in ad hoc network to control the antenna system by modifying each layer in the network protocol stack. P. SaiKiran [15] proposed a full system cross layer design architecture for MANET using Directional Antennas. The aim of the proposed protocol design is for the protocols of different layer to share the data with other layer protocols. All the protocols can share the data by using the Status Information. The legacy protocols also still available in stack, these types of protocols are not followed the cross layer design to calculate the performance of the cross layer design approach by considering the following protocols at different layers. The two channels one control channel and another for Data channel. At MAC layer uses Smart Medium Access Control Protocol which is a protocol for MANET using Directional Antennas. SMAC supports cross layer design approach by providing the Node Mobility information and uses an alternate method to exponential back off timer to increase the throughput. At network layer

Author [15] wants to propose a routing protocol that used the node mobility information provided by the SMAC protocol. And needed the location based routing protocol that uses Link state method to share the information with the nodes. At Transport layer needed, connection oriented communication to the applications. Need to provide IP auto configuration using State full addressing protocol for MANET. [23][24]

Asymptotically Optimal Back off (AOB) Mechanism
AOB uses two simple estimates: the slot utilization and the average size of transmitted frames are used to calculate the network contention level. These measurements are humble and can be found by exploiting information that is already obtainable in the standard protocol. Standard of 802.11 access mechanism can be used to extend the AOB without demanding any added hardware. [16]

Mobility Model: Mobility of the mobile users can be described in this model. This signifies the mobile user position, speed and increase in speed change over time. The number of mobility modes is given below. Random Walk Mobility Model, Random Waypoint Mobility Model, Boundless Simulation Area Mobility Model, Gauss-Markov Mobility Model, Proba Walk Mobility Model, City Section Mobility Model, Group Mobility Model, RPGM (Reference Point Group mobility Model), Column Mobility Model.[25]

Random way point:
[3]Fan Bai .Yet al describes this model is a well designed model, at every time each node select a random target and travel on the way to it with a speed in [0,Smax], where Smax is the highest permissible speed for a node.

After reaching the target, the node stops for a duration defined by the "pause time" parameter. After this duration, it again selects a random target and replicates the whole procedure again until the process ends. The Random Waypoint is simplicity of implementation and investigation so it's broadly accepted in MANET.

It is a clever model but it is lacking to imprison the following features:
    1) Spatial dependence of movement among nodes.
    2) Temporal Dependence of movement of a node over time.
    3) Existence of barriers or obstacles constraining mobility. [3][25]

Conclusion

Link-state routing or distance-vector routing is used by the topology based routing protocols to get the topology information at the same time the geographical-based routing protocols uses the location updates to get geographical data. The routing table can be referred by the topology-based routing technique to obtain the routing information and geographical-based routing uses the neighbours' location table. Large networks mostly use the link state routing protocols because of their speedy convergence and good reliability, so it is better than the distance vector routing.

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