Detail Analysis of MANET and Heterogeneous Routing Protocols

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***Abstract*:- The Identification of stable and efficient routing protocol plays a very critical role in places where wired network are neither available nor economical to deploy. This paper provides an characteristics of the routing protocols by presenting their overview and then analyze their performance. The study will be helpful in identifying which protocol is best suitable and how the performance of that protocol can be further improved. It also present a view of the various routing protocols present in the Mobile Ad-Hoc Networks (MANETs) and Heterogeneous Networks compare them as to see the best performance oriented. In future MANET's, denser mediums will be used with increasing number of applications, therefore, the study will be of great interest to researchers in getting an idea about which protocol to consider under sparse/denser medium environments for efficient and stable routing.**

Key terms: Multiple-hop Cellular Networks, Heterogeneous Networks, Mobile Ad hoc Networks

1. INTRODUCTION

Mobile Ad hoc Network (MANET) is a special type of wireless mobile network in which a collection of mobile hosts with wireless network interface may form a temporary network, without aid of any established infrastructure or centralized administration. The application ranges from civilian disaster recovery and military. Routing is the MANET faces special challenges because of its infrastructure less network and its dynamic topology. The tunnel-based triangle routing of mobile IP works well only for fixed infrastructure network to support the concept of "home agent". But when all hosts move, such a strategy cannot be directly applied. Traditional routing protocols for wired networks like distance vector or link state are no longer suitable for ad hoc wireless networks. In an environment with mobile hosts as routers, changes in network topology may be slow and this process could be expensive due to the low bandwidth.

Routing protocols for MANET can be roughly divided into Proactive and Reactive. In Proactive routing each host continuously maintains complete routing information of the network. Both link state and Distance vector belong to proactive routing. The Reactive scheme, invokes a route determination procedure only on demand through a query for reply approach**,**

MANET AND HETEROGENEOUS NETWORK PROTOCOLS

There are many routing protocols which have been proposed for MANET and Hetero networks. The MANET include: Ad hoc on Demand Distance Vector(ADOV), Dynamic Source Routing(DSR), Destination Sequenced Distance Vector (DSDV), Temporally Ordered Routing Algorithm (TORA), Optimized Link State Routing(OLSR).And The Hetero NET include some integrated networks such as Cellular Relay Interfacing Protocol (CRIP), Multi-hop 3G Spontaneous Network(M3GSN), Universal Cellular Ad hoc Network (CCAN), A-GSM, OANS. These protocols have been investigated in the Past years. The performance investigation of these protocols, on the MANETs, and Hetero nets has produced many useful results.

The objective of this research is to carryout the systematic performance study on MANET and Heterogeneous network protocols .In this paper a performance study is to be conducted for Heterogeneous networks where some specific qualitative metrics like are considered and investigated for future enhancement.

The rest of this paper is organized as follows: Section II includes the related works. The MANET routing protocol description is summarized in Section III. Hetero net routing protocol description is summarized in Section IV. The Performance metrics are described in Section V. The paper is concluded in Section VI.

2. RELATED WORKS

George A, et al, proposed mobile communications shift paradigm is the successful development is traditional single hop cellular systems where a mobile station (MS) communicates directly with a base station (BS). The success of the second generation (2G) cellular networks and the clouds of 3G over our heads the need for higher data rates and bandwidth is an important concern for the industry. Another paradigm of the mobile communications is the multi - hop ad hoc networks which are self organizing, rapidly deployable without any site planning unlike traditional cellular networks. Thus it works on the concept of peer to peer networks. Thus every node can act as the intermediary station that relays packets of other nodes towards their destinations that otherwise cannot be reached using a single hop transmission[3]. MANETs are easy to deploy because of their use of unlicensed spectrum of IEEE 802.11. However this architecture has its own set of drawbacks which include less reliable performance as the channel connection and interference between nodes are more difficult to predict or control. Another failure reason is the multi-hop paths between source destinations are more vulnerable to the node mobility and node failure.

Feeney et al. [9] discussed a similar architecture that allows replacing a low data rate transmission with a two-hop sequence of shorter range, to provide higher data rate transmissions, using mobile relays. The difference from new relay proxy discovery protocols, opportunistic relay protocol (ORP), is proposed and studied in [9]. ORP allows MSs to increase their transmission data rate using a two-hop transmission with shorter transmission range in each hop, by using an intermediate MS as a relay, such that a higher data rate can be achieved with the shorter transmission range. Furthermore, ORP differs from the proxy discovery algorithms proposed in discovering proxy experimentally by opportunistically making frames available for relaying. MSs identify them as suitable relays by forwarding these frames. Lastly, a distinct feature of ORP is that it does not rely on observations of the received signal strength to infer the availability of proxy and transmit rates.

Luo et al. explained two algorithms greedy and on-demand proxy discovery algorithms. In general, the greedy proxy discovery protocol is proactive and the on-demand proxy discovery protocol is passive. The greedy proxy discovery requires a greedy path to reach a proxy client with high HDR downlink channel rate. A greedy path is constructed by a mobile client forwarding the route request message (RTREQ) to its neighbor client with the best HDR downlink channel rate for each hop[5]. However, this greedy path may not always locate the proxy client with the best overall channel rate for the destination client. The on-demand proxy discovery always finds the proxy client with the best channel rate at the expense of RTREQ message flooding. The drawback encountered in UCAN is the potential stability issue related to the interference in the unlicensed ISM band.

M.Pandey and et al, presented an analytical study of the average jitter of AODV routing protocol in wireless sensor networks, for different simulation time and mobility conditions. The performance measurements were carried out for the AODV routing protocol for different simulation times and network topologies and under different mobility conditions. The paper investigated the impact o different mobility models on the performance of 105 nodes (500x500) m^2 wireless sensor networks. Although the presented results did not present a steep comparative orientation of the results towards a specific routing protocol but the comparative study leads towards the some interesting results [11].

3. MANET ROUTING PROTOCOL

MANET is a collection of wireless mobile nodes forming a temporary/short-lived network without any fixed infrastructure where all nodes are free to move about arbitrarily and where all the nodes configure themselves. In MANET each node acts both as a router and as a host & even the topology of network may also change rapidly. Some of the key challenges in MANET include: 1) Efficient and Stable routing
2) Dynamic topology 3) Network Scalability 4) Network overhead 5) Quality of Service 6) Power Management 7) Security. Any routing algorithm has to be taken into consideration that it can appear and disappear at any time. The various routing algorithms that have been provided have both their advantages and disadvantages. In the following section we present the various routing protocols.

3.1 PROACTIVE ROUTING PROTOCOLS

These protocols will continuously try to determine the layout of the network. It achieves this by exchanging packets containing topology information between the various mobile nodes. As a result the delay in determining the route to be taken is minimal. This is very important for real time data.

A. OPTIMISED LINK STATE ROUTING (OLSR)

It is a proactive link-state routing protocol optimized for mobile ad-hoc networks, which can also be used on other wireless ad-hoc networks. It uses Hello and Topology Control (TC) messages to discover and then disseminate link state information throughout the aforementioned network. Individual nodes use this information to compute next hop destinations for all nodes in the network. This is done using shortest hop forwarding paths. This protocol is basically based on the link state algorithm and it has been modified and optimized to efficient routing over mobile ad hoc network. This protocol adapt according to the changes of the network without creating control messages overhead due to the protocol flooding nature. Link-state routing protocols such as OSPF and IS-IS elect a designated router on every link to perform flooding of topology information. In wireless ad-hoc networks, there is different notion of a link, packets can and do go out the same interface; hence, a different approach is needed in order to optimize the flooding process.

B. DYNAMIC DESTINATION SEQUENCED DISTANCE VECTOR ROUTING (DSDV)

It is a table-driven routing scheme for ad hoc mobile networks based on the Bellman-Ford algorithm. It was developed by C. Perkins and P. Bhagwat in 1994. The main contribution of the algorithm was to solve the routing loop problem. Each node maintains a list of all destinations and number of hops to each destination. Each entry in the routing table contains a sequence number, the sequence numbers are generally even if a link is present; else, an odd number is used. The number is generated by the destination, and the emitter needs to send out the next update with this number. Routing information is distributed between nodes by sending full dumps infrequently and smaller incremental updates more frequently. The broadcast of route updates is delayed by settling time. The

only improvement made here is avoidance of routing loops in a mobile network of routers. With this improvement, routing information can always be readily available, regardless of whether the source node requires the information or not. In DSDV, a sequence number is linked to a destination node, and usually is originated by that node (the owner). The only case that a non-owner node updates a sequence number of a route is when it detects a link break on that route. An owner node always uses even-numbers as sequence numbers, and a non owner node always uses odd-numbers. With the addition of sequence numbers, routes for the same destination are selected as under:
1) A route with a newer sequence number is preferred.
2) In case two routes have a same sequence number, the one with a better cost metric is preferred.

3.2 REACTIVE ROUTING PROTOCOLS

These kinds of protocols only find a route to the destination node when there is a need to send data otherwise it does not keep routing information with itself stored. Whenever the source nodes want to transmit data it will start a route discovery procedure by transmitting route requests throughout the network. The sender will then wait for a response from the destination node or an intermediate node that can act as a relay to the destination.

C. DYNAMIC SOURCE ROUTING (DSR)

It is an Ad hoc routing protocol which is based on the theory of source-based routing rather than table-based. This protocol is source-initiated rather than hop-by-hop. It is a simple and efficient routing protocol designed specifically for use in multi-hop wireless ad hoc networks of mobile nodes. DSR allows the network to be completely self-organizing and self-configuring, without the need for any existing network infrastructure or administration. Dynamic Source Routing, DSR, is a reactive routing protocol that uses source routing to send packets. It uses source routing which means that the source must know the complete hop sequence to the destination. Each node maintains a route cache, where all routes it knows are stored. The route discovery process is initiated only if the desired route cannot be found in the route cache. To limit the number of route requests propagated, a node processes the route request message only if it has not already received the message and its address is not present in the route record of the message. The protocol is composed of the two main mechanisms of "Route Discovery" and "Route Maintenance", which work together to allow nodes to discover and maintain routes to arbitrary destinations in the ad hoc network.

.1) Route Discovery

Route Discovery is used whenever a source node desires a route to a destination node. First, the source node looks up its route cache to determine if it already contains a route to the destination. If the source finds a valid route to the destination, it uses this route to send its data packets. If the node does not have a valid route to the destination, it initiates the route discovery process by broadcasting a route request message. The route request message contains the address of the source and the destination, and a unique identification number. An intermediate node that receives a route request message searches its route cache for a route to the destination. If no route is found, it appends its address to the route record of the message and forwards the message to its neighbors. The message propagates through the network until it reaches either the destination or an intermediate node with a route to the destination.

2) Route maintenance

Route Maintenance is used to handle route breaks. When a node encounters a fatal transmission problem at its data link layer, it removes the route from its route cache and generates a route error message. The route error message is sent to each node that has sent a packet routed over the broken link. When a node receives a route error message, it removes the hop in error from its route cache. Acknowledgment messages are used to verify the correct operation of the route links. In wireless networks acknowledgments are often provided as e.g. an existing standard part of the MAC protocol in use, such as the link layer acknowledgment frame defined by IEEE 802.11.

D. AD HOC ON DEMAND DISTANCE VECTOR ROUTING PROTOCOL (ADOV)

It is a variation of Destination-Sequenced Distance- Vector (DSDV) routing protocol which is collectively based on DSDV and DSR. It aims to minimize the requirement of system-wide broadcasts to its extreme. It does not maintain routes from every node to every other node in the network rather they are discovered as and when needed & are maintained only as long as they are required. The establishment of unicast routes by AODV is explained as under:

1) Route Discovery

AODV initiates a route discovery process using Route Request (RREQ) and Route Reply (RREP). The source node will create a RREQ packet containing its IP address, its current sequence number, the destination's IP address, the destination's last sequence number and broadcast ID. The broadcast ID is incremented each time the source node initiates RREQ. If the RREQ is lost during transmission, the source node is allowed to broadcast again using route discovery mechanism.

2) Expanding Ring Search Technique

The source node broadcasts the RREQ packet to its neighbours which in turn forwards the same to their neighbours and so forth. Especially, in case of large network, there is a need to control network-wide broadcasts of RREQ and to control the same; the source node uses an expanding ring search technique. In this technique, the source node sets the Time to Live (TTL) value of the RREQ to an initial start value. If there is no reply within the discovery period, the next RREQ is broadcasted with a TTL value increased by an increment value. The process of incrementing TTL value continues until a threshold value is reached, after which the RREQ is broadcasted across the entire network.

3) Setting up of Forward Path

When the destination node or an intermediate node with a route to the destination receives the RREQ, it creates the RREP and uni-cast the same towards the source node using the node from which it received the RREQ as the next hop. When RREP is routed back along the reverse path and received by an intermediate node, it sets up a forward path entry to the destination in its routing table. When the RREP reaches the source node, it means a route from source to the destination has been established and the source node can begin the data transmission.

4) Route Maintenance

A route discovered between a source node and destination node is maintained as long as needed by the source node. Since there is movement of nodes in mobile ad hoc network and if the source node moves during an active session, it can reinitiate route discovery mechanism to establish a new route to destination. Conversely, if the destination node or some intermediate node moves, the node upstream of the break initiates Route Error (RERR) message to the affected active upstream neighbors/nodes. Consequently, these nodes propagate the RERR to their predecessor nodes. This process continues until the source node is reached. When RERR is received by the source node, it can either stop sending the data or reinitiate the route discovery mechanism by sending a new RREQ message if the route is still required.

E. TEMPORALLY ORDERED ROUTING ALGORITHM (TORA)

It is a distributed highly adaptive routing protocol designed to operate in a dynamic multi-hop network that is based on the link reversal algorithm. The main concept of this protocol is that the network for any source node can be "visualized" as a Directed Acyclic Graph (DAG) rooted at the destination node. When a link between the source and the destination fails, the nodes reverse the direction of the links and update the previous nodes in the path. Additionally, each node maintains multiple paths to a given destination and is capable of detecting any partitions in the network. To accomplish such behavior, a value, "height," is associated with each node at all times. These values can be ordered in comparison to the "height" of each neighboring node. Data flow occurs from a node with a higher value to a node with a lower value. When a node cannot detect the height value of one of its neighbors, it does not forward data

4. HETERONET ROUTING PROTOCOL

The future of wireless communication lies in the ubiquitous networks that will be able to provide availability anywhere. These networks will be a combination of both the wired and wireless networks. I.e. Cellular networks combined with IEEE802.XX networks where you can access both the network through access points and also through direct connection with the base station. Thus a Heterogeneous communication network provides transparent and self configuring able WLAN. The basic components are mobile stations (MS's), BS's/ APs. And a core (IP) network serving as the communication bridges for MS's. WLAN's can operate in infrastructure e.g. single hop mode where connectivity is provided by the AP or in MANET mode where devices can communicate with each other through multi-hop routing. A connection from a MS to a BS/AP can be established by a single hop or using multi-hop when the MS is out of the coverage of the corresponding BS/AP as shown in Figure.1. [8].

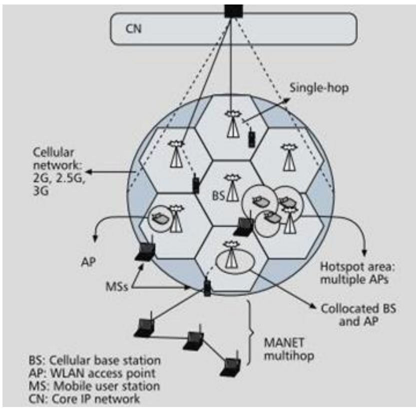


Figure 4.1.Heterogeneous Network Architecture

Although there is still a far of time to when the heterogeneous networks will be implemented there are three unique features significantly affecting the design of integrated solutions, namely , the availability of multiple interfaces for a MS, the integration of cellular networks and WLAN's and multi-hop communication. These issues need to be addressed to provide an integrated transparent and self configurable service**.** [11] Heterogeneous networks will require the maintenance and configuration of multi-hop paths and available network interfaces due to the transient nature of the networks (relay MSs). The real challenge is to devise algorithms to discover and cope up with changing topology of the network. Consider a scenario, in a university campus where a large number of mobile users that can act as relay MSs, are spread over the campus. At noon, the users may flock towards the cafeteria and users in close proximity could form a multi-hop network.

The various architectures which have been proposed are as follows.

4.1 CELLULAR RELAY INTERFACING PROTOCOL (CRIP)

The architecture proposed in [7], namely integrated cellular and ad hoc relaying (CRIP), features a typical example for M3GSNs with fixed relays, which makes use of the conventional cellular technology and ad hoc networking technology to realize the dynamic load balancing. The key idea of CRIP is to strategically locate a number of fixed relays, called ad hoc relay stations (ARSs), and use them to divert traffic from one possibly congested cell to other non-congested cells. Consequently, the congestion can be mitigated or even eliminated. Next, CRIP makes it possible to handle handover calls for MSs moving into a congested cell, or to accept new call requests originated from MSs in a congested cell. As shown in Figure.2.

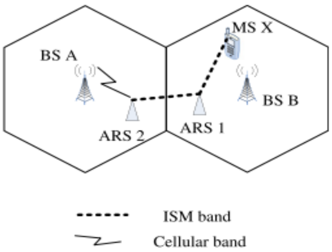


Figure 4.1.1. Primary Relaying Strategy in CRIP

If a MS X does not find a cellular frequency channel in cell B to set up a communication link with BS B, it will send the traffic to its nearest ARS, ARS 1, using frequency bands other than the cellular band, such as the ISM band. The ARS 1 will relay the traffic, using the ISM band again, to another ARS, ARS 2, in the neighboring cell, cell A. Finally, ARS 2 will forward the traffic to BS A using the cellular frequency channel. This provides a cost-effective way to overcome the congestion problem by dynamically balancing the traffic load among different cells.

4.2 MULTI-HOP 3G SPONTANEOUS NETWORK (M3GSN)

Lin and Hsu proposed multi-hop cellular network (M3GSN) in the year 2000, which is considered as one of the few pioneer works reported in the literature using multi-hop transmissions in the cellular networks. They pointed out two ways to construct a M3GSN, which are shown in Figure. 3.

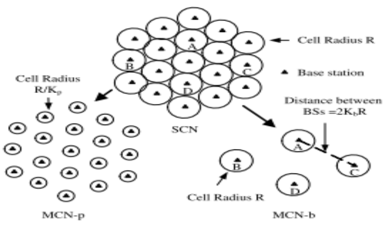


Figure 4.2.1. Structure of M3GSN

One is referred to as M3GSN-p, which reduces the transmission range of a BS (or MS) and keeps the same number of BSs in the service area. The other one, M3GSN-b, on the contrary, reduces the number of BSs such that the distance between two neighboring BSs becomes larger while keeping the transmission range of a BS or a MS. In both cases, the MS may not be able to reach the BS within one hop. Hence, M3GSN does not have a problem to fit into the current state of technology. In an effort to show the advantages of M3GSN, Lin and Hsu have considered only intra-cell network traffic. However, under inter-cell traffic conditions, the benefits of spatial reuse through peer-to-peer communications, if any, and the effectiveness of the M3GSN architecture might be poor.

4.3 COHESIVE CELLULAR AND AD HOC NETWORK (CCAN)

In the 3G wireless data networks, channel quality usually determines the QoS of the connection from a MS to its BS. When MS‘s are experiencing poor channel conditions this bottleneck actually limits the aggregate throughput of a cell. Thus a multi-hop cellular network which was proposed in which is a new architecture namely Cohesive Cellular and Ad Hoc Network (CCAN) by opportunistically using ad hoc network such as Industry Scientific Medical (ISM) Bandwidth. As shown in Fig 4.
CCAN consists of a 3G cellular network namely CDMA 2000 Evolution-Data Only also known as High Data Rate (HDR) , and Wi–Fi to provide high data services for any user. If the HDR BS is not able to provide a high data rate to a specified MS,

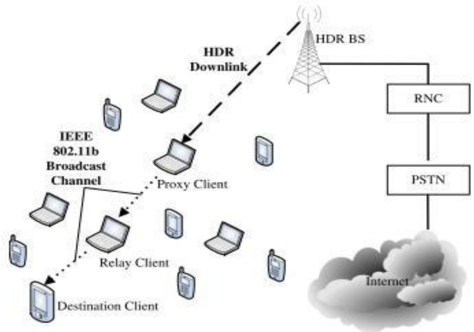


Figure 4.3.1 CCAN Architecture

4.4 A-GSM & ODMA

The ad hoc global system for mobile communications (A-GSM) architecture allows GSM dual-mode MSs to relay packets in MANET mode and provide connectivity in dead spot areas, thereby increasing system capacity and robustness against link failures. The dual-mode MSs in are equipped with a GSM air interface and a MANET interface; when one interface is being The MSs have an internal unit called a dual-mode identity and internetworking unit (DIMIWU), which is responsible for performing the physical and MAC layer protocol adaptation required for each air interface (i.e., GSM or MANET A-GSM).

4.5 OVERLEY WITH ADHOC NETWORK FOR SCALABLITY (OANS)

This Network investigates some of the techniques by which the capacity of a cellular network can be enhanced, including bandwidth allocation, access control, routing, traffic control, and profile management. The OANS architecture advocates six steps of self-organization for the physical, data link, and network layers to optimize the network capacity: neighbor discovery, connection setup, channel assignment, planning transmit/receive mode, mobility management and topology updating, and exchange of control and router information. Multiuser detection (MUD) is also suggested for the physical layer since MUD is an effective technique to reduce the excessive interference due to multi-hop relaying. In the MAC layer, if transmissions are directed to a node through several intermediate nodes by multi-hop, clever frequency channel assignments for each node can significantly reduce interference and could result in better performance. In the network layer, for enhancing system capacity, multi-hop routing strategy must take into account the traffic, interference, and energy consumption.

Table 4.1. Table of MANET Protocol design & Performances

Protocol Design	Technology	Station	Mode	Purpose	Performance
OLSR	MANETs	Multipoint relaying Devices	Single mode	This protocol is basically based on the link state algorithm and it has been modified and optimized to efficient routing over mobile ad hoc network	OLSR protocol at each node discovers 2-hop neighbor information and performs a distributed election of a set of multipoint relays (MPRs).
DSDV	MANETs	Mobile station	Dual mode	Table-driven routing scheme for ad hoc mobile networks based on the Bellman-Ford algorithm.	Avoidance of routing loops in a mobile network of routers.
DSR	MANETs	Mobile station	Dual mode	It is a reactive routing protocol and based on the theory of source routing.	it avoids routing loops easily because the complete route is determined by a single node instead of making the decision hop-by-hop.
AODV	MANETs	Mobile station	Dual mode	establishment of uni- cast routes	aims to minimize the requirement of system-wide broadcasts to its extreme.
TORA	MANETs	Mobile station	Dual mode	based on the link reversal algorithm	designed to operate in a dynamic multi-hop network

Table 4.2. Table of Heterogeneous Protocol design & Performances

Protocol Design	Technology	Station	Mode	Purpose	Performance
CARI	Cellular system, WLAN	Fixed relaying Devices	Dual mode	Congestion Problem From Diverting the traffic from hot cell to cold cell	Relaying devices (used for network relaying)
CCAN	3G cellular system, WLAN	Mobile Client	Dual mode	Increase downlink Through the cellular network by the Wi-Fi based ad-hoc network	Relaying traffic in HDR downlink to proxy client and route request is initiated by the destination
M3GSN	Cellular System, WLAN	Mobile station	Dual mode	Solving the capacity problem by upgrading BS's	Reducing the transmission power of BS . Thus Increase the bandwidth utilization
A- GSM	Cellular system, MANETs	Gateway	Dual mode	Providing coverage	Reduction in Transmission power
OANS	Cellular system, MANETs	Mobile station	Single mode	Channel assignments	Reduce the excessive interference

5. PERFORMANCE ANALYSIS

In order to better understand the various protocols in the various design proposed for the MANET and Heterogeneous networks.

Table 5.1 and 5.2 shows the qualitative metrics of MANET and HETERO NET protocols. Depending on the characteristics we have apply the weight value to each qualitative metrics for analyzing. and shows the performance in figure 5.1 and 5.2, as to how and which one is the best scenario to combine and produce a new one.

Table.5.1 Qualitative Metric of MANET Protocols

Protocols/ Qualitative Metrics	Loop	Mode	Multicasting	Routing scheme	Routing metric	Design	Security	Reliability	Nature
OLSR	Y	Single	N	Flat	Shortest	simple	N	N	Pro
DSDV	Y	Dual	N	Flat	Shortest	simple	Y	N	Pro
DSR	Y	Dual	N	Flat	Shortest	simple	N	N	Re
AODV	Y	Dual	Y	Flat	Shortest	simple	N	Y	Re
TORA	Y	dual	N	Flat	Shortest	simple	N	N	Re

Fig.5.1 MANET Performance

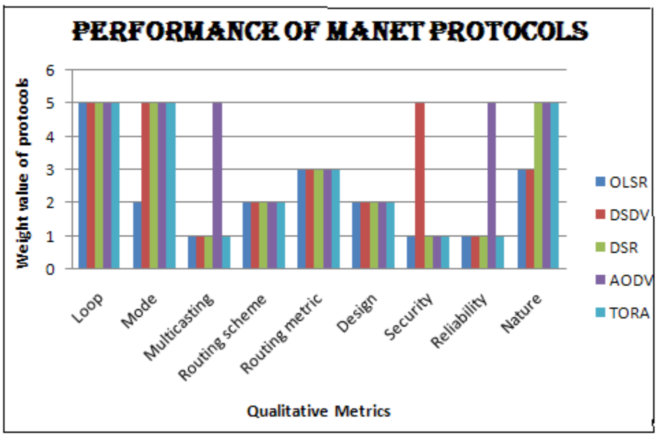
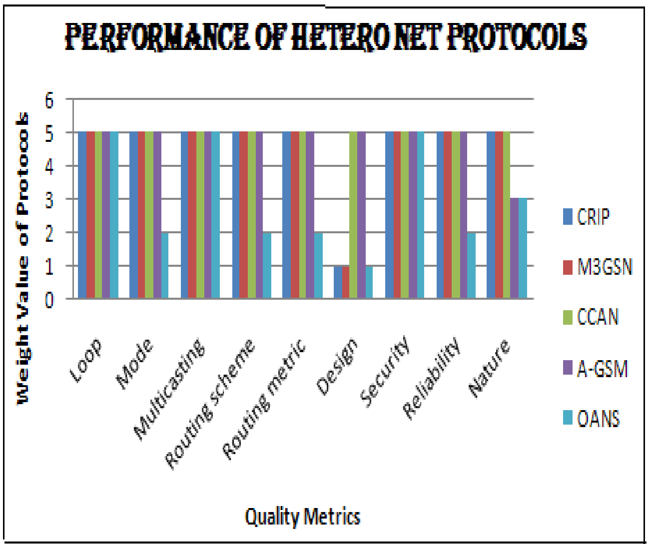


Table.5.2 Qualitative Metric of Hetero net Protocols

Protocols/ Qualitative Metrics	Loop	Mode	Multicasting	Routing scheme	Routing metric	Design	Security	Reliability	Nature
CRIP	Y	Dual	Y	Tree	Longest	Simple	Y	Y	Re
M3GSN	Y	Dual	Y	Tree	Longest	Simple	Y	Y	Re
CCAN	Y	Dual	Y	Tree	Longest	Hard	Y	Y	Re
A-GSM	Y	Dual	Y	Tree	Longest	Hard	Y	Y	Pro
OANS	Y	Single	Y	Flat	Shortest	Simple	Y	N	Pro

Fig.5.2 HETERO NET Performance



VI. CONCLUSION

During the current research, several areas have been identified that could be further investigated. The major area of immediate research is the investigation of novel routing protocol which can handle multiple attacks, intelligent new routing protocol which is capable of taking decision on varying environments. In this paper presented a performance analysis for MANET and Hetero net protocol using qualitative metrics with the impact of the characteristics. It is found that in most of the analysis scenario the AODV protocol in MANET and CCAN in Hetero net is better for comparing the some of the metrics. We must point out that the work in completely orthogonal to the design of protocols and its qualitative metrics.

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