THE CLASSIFICATION AND ANALYSIS OF MANET ROUTING PROTOCOLS

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ABSTRACT

In Mobile Ad-hoc Network (MANETs) mobile nodes are grouped together by using wireless medium that can fail due to its dynamic infrastructure and mobility. Routing protocols are used to facilitate communication among mobile nodes. To provide communication facility among mobile nodes of network routing protocols are used. The main target of routing protocol is to provide path among nodes that should be correct and efficient. Discovery and maintenance of route should have with minimum bandwidth and overhead. This paper investigates and classify Ad hoc On-Demand Distance Vector (AODV), Dynamic Source Routing (DSR), Destination-Sequenced Distance-Vector (DSDV), Temporally Ordered Routing Algorithm (TORA), Multimedia Mobile Wireless network (MMWN), Zone Routing Protocol (ZRP) and Wireless Routing Protocol (WRP).

1. INTRODUCTION

Communication technologies and networking are getting advance now a days. For common activities cell phones and laptops like portable devices are used anywhere by people. Mobile adhoc network is one of the wireless network which is self-configuring and self-location changing. No base stations are used by MANET, every node of network works as router itself. Movements of nodes in MANETs are arbitrarily a change in topology occurs unpredictably. In addition, range Of nodes for transmission are limited in MANET. Due to these limits no direct transmissions can be done by same node [1,2]. Multiple hops are taken for potential path in MANETs, routing is challenging issue in MANET that is complicated due to mobility of nodes. Changes in routes may occur frequently, update of communication links continuously occurs, and sending of messages also done frequently, Hence creation of traffic arises due to this control. Common specification in different devices used by MANET is its limited energy [3].In energy consumption conductive radio waves, resubmission, collision and transmission all are effective. For this purpose strong protocols are needed that manages effective and efficient energy by using different techniques. To achieve efficient routing multiple routing protocols have been proposed. Every algorithm performs different task like, discovering route or maintaining existing known routes. Table driven or proactive routing protocols and on demand or reactive routing protocol are two categories of MANET routing protocol [4].

In this category routing information is stored in routing tables maintain by each node of network. Latest view of Benefit of Table driven protocols is that they do not need to initiate route discovery procedure to reach up to destination but they need massaging overhead because they need to maintain continuously up to date information in its routing table that reduces throughput, consumes power and bandwidth specially in large area networks.

These algorithms create routes when node demands for it. Route discovery procedure is invoked by these protocols during transmission between source and destination. These routes remain active until transmission becomes complete or when they are not used for long time [5]. Benefit of this category protocol is reduced massaging overhead but for new route discovery, delay occurs that is main drawback of these protocols [6].

Energy consumption is an important factor while dealing with MANET, because every node of network contains batteries with some limited power supply for processing. This is challenging issue in MANET because each node forwards packages between nodes as a router and an end system itself so additional energy is needed [1]. In this paper we deal with following metrics to compare different MANET protocols. Routing Overhead

- End to end delay
- Throughput or PDR
- Packet retransmitted
- Energy consumption
- Dropped packets

This paper is organized as follows; in section 2 the working of routing protocols AODV, DSR, DSDV, ZRP, WRP, MMWN, and TORA is given. In section 3, performance metrics are taken in to consideration, while comparison result is represented in section 4 and section 5 contains conclusion of paper.

2. WORKING OF DIFFERENT MANET ROUTING PROTOCOLS:

2.1 AdhocOn Demand Distance Vector:

On the combine features of DSR and DSDV working of

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AODV depends on them. No route maintenance is done by AODV between nodes in the network but demand of route is made by network nodes then routes are discovered and maintained. Unicast route establishment contains some steps those are:

2.1.1 Route Discovery

When any source node S needs to transmit packet to destination node D, it first check in its routing table for route entries towards that destination node. If there is any entry regarding that route is available in routing table then it transmits the packet to the appropriate neighbor towards destination and if it is not there then procedure of discovery of route is initiated by sending RREQ packet from source node. This packet contains source IP address, Destination IP address, its current sequence number, last sequence number and ID of broadcast. Every time when route request is initiated by source node it increments broadcast ID. IP address and Broadcast ID combine makes a unique identifier for RREQ packet and for making timeliness of every data packet sequence numbers are used. When route is source to its neighbors source setup the timer for reply. Every node maintains a reverse path to source in its routing table during the process of RREQ. This will help to forward RREP to source. Lifetime is entered with reverse route entry in its routing table, if route is not used within that life time it will be deleted. AODV also allows initiating route discovery process in case if RREQ is lost during transmission [5,8]. Figure 1 illustrates route discovery procedure in AODV routing protocol.

2.1.2 Expanding Ring Search Technique:

During broadcast of RREQ between source, intermediate nodes and destination, source node uses expanding ring search technique in order to control RREQs network broadcast. (TTL) time to live value is used by this technique, TTL value of RREQ is set by source node as its initial value. If source node does not get any response within that time of discovery, the TTL value is incremented and next RREQ will start broadcasting. TTL incremented value process will continue until it reaches to its threshold value. Across entire network RREQ is broadcasted after reaching to threshold [5,8,9].

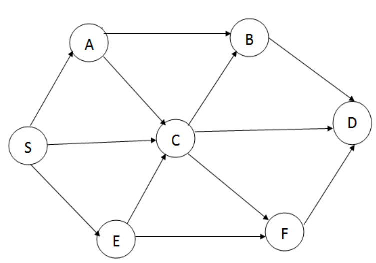

Figure 1: PREQ diagram for AODV when source S sends a request to destination

2.1.3 Setting up of forward path:

After receiving RREQ from source, every intermediate or destination node creates a RREP and sending back to source by unicasting technique. When a reverse path is generated, and RREP is routed back, an entry about that route will be entered in routing table of destination. When source node receives RREP successfully that means route is created between source and destination and transmission of data can be begin by source node [5,8,9].

2.1.4 Route Maintenance:

Due to mobility in adhoc networks route discovery process can be reinitiated by source node in case if source node has taken move from one position of network to another. During the movement of neighbor nodes or destination nodes their upstream nodes will initiate RERR (route error message) and broadcast it to its active predecessor nodes that are affected by that movement. After receiving route error message the source node either reinitiates route discovery process or stops transmission of data depending upon requirement of route.

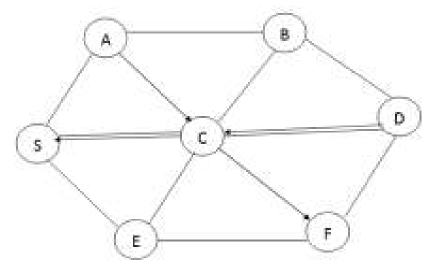

Figure 2: PREP diagram for AODV when destination D sends reply to source S.

Unicast and multicast transmission of packets are supported by AODV protocol. Instead of shortest route, least congested paths are favored by AODV. In case of topological changes AODV gives quick response to its effected active paths. On data packets no additional overheads are put by AODV. Self-detection of medium broadcast between nodes is expected by AODV. Valid route expiration is also possible and finding that expiry time is difficult. Performance of different metrics may decrease as the size of network increase [5,8,9].

2.2 Dynamic Source Routing Protocol:

DSR is an on-demand routing protocol. It creates routes on demand bases instead of hop by hop routing. This algorithm is particularly design for wireless mobile nodes adhoc networks by using multi hop techniques. DSR permits network to be self-configuring and self-organizing and do not need any currently existing topology infrastructure. Route discovery and route maintenance are the two main parts of this protocol. Information about the discovered path/route is stored in cache and that cache is maintain by each node of network.

When source node S needs to transmit packet to destination node D it firstly checks in its cache about the route entry, if that route is available in its cache then it transmits massage through that path and if route to destination is not there and entry of that route is deleted from cache due to remain idle for long time then sender will start broadcasting packet to all its around to ask from neighbor nodes for available route towards destination. Upto the discovery of required route, sender node will wait [5].

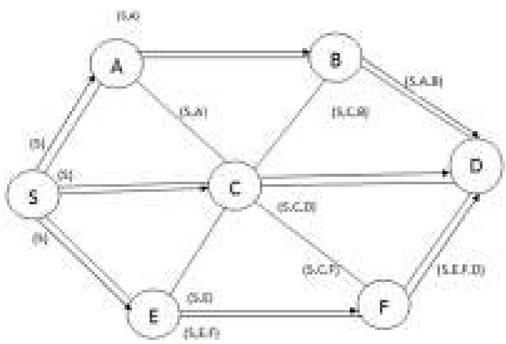

Figure 3: Route discovery diagram for DSR when source S sends a request to destination D.

Till the route is discovered sender node is free to perform other transmissions to different nodes.When neighbor nodes receive route request,they check in its cache whether the required route to destination is available or not. If any node have route information in its cache they send route reply packet o source.They insert an entry about that route in its cache also, so that it can be used in future. When intended packet transmission started and packet is received by any intermediate node then it checks address stored in packet header if it matches then it receives that data and if it does not matches then forwards it further according to route information attached on that packet. Discovery of route procedure is described in Figure 3.Route maintenance is available in DSR algorithm because adhoc networks routes can be failed any time.Route maintenance procedure keeps in view whole network constantly, if there is any route failure then it changes its route cache entries. Figure 4 illustrates route reply procedure between source node and destination node using DSR protocol.

Advantages:

- It does not need to be store routing table because it contain route address in its packet header

Drawbacks:

- Increase in Routing overhead is main issue when topology of network changes or new route needs to be discovered.

By using intelligent caching techniques at network nodes we can reduce overhead but have expensive memory and resources of CPU. Every packet includes source route header that requires remaining bandwidth overhead. The main problem of DSR is scalability, when route queries arise at nodes they use route caches that causes continues repetitive updates and uncontrolled replies at caches on host nodes. The flooded Propagation of all query massages cannot be stop by using earliest queries. As the size of network increases, the size of control packets and massage packets also increases. This causes the degradation in the performance of protocol after sometime [8].

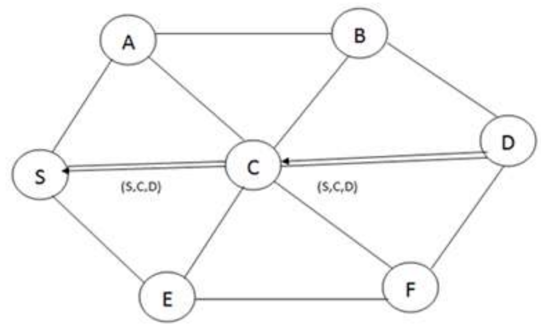

Figure 4: RREP diagram for DSR when source S receives Route reply from Destination D

2.3 Temporary Ordered Routing protocol:

Multihop dynamic networks are operated by using this highly adaptive routing protocol TORA.When source needs to transmit data to any destination the direction of link between them is created by height parameter used by this protocol. Towards a simple destination there may be multiple routes available but it is not important that it contains any short route. When source needs to create route it starts sending QUERY packets to all its around nodes. All networks nodes on receiving that QUERY packet forwards that packet to all its other nodes of network until destination found. Node that receives this QUERY packet, they send UPDATE packet that contains a value of height greater than its neighbor height value of received update packet node. Through this it creates link between original senders of packet to the node that has created that packet.

When node confirms about expire of route towards the destination, so node will set its height and transmits UPDATE packet to its neighbors. If towards destination there is infinite attempt of nodes then route discovery procedure is initialized again as described above. When partition of network occurs then node creates CLEAR packet in order to cancel routing in adhoc network [5,11]. Figure 5 and 6 gives pictorial description for working of TORA routing protocol.

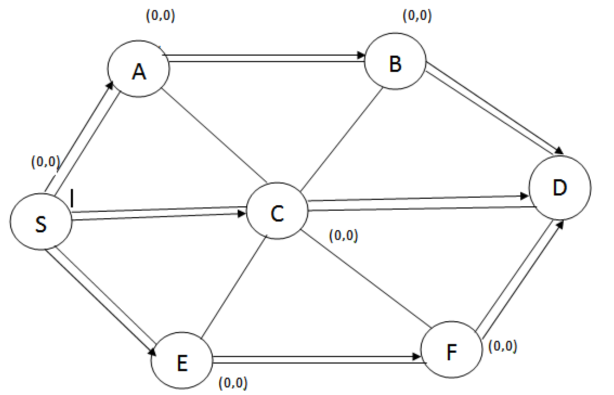

Figure 5: Broadcast Query diagram of TORA when Source S broadcast packet to Destination D

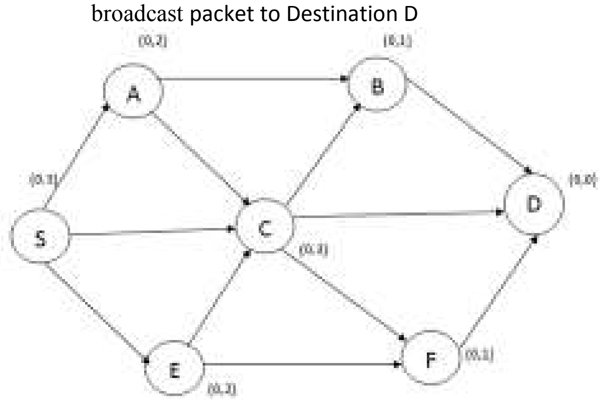

Figure 6: Example diagram for distribute UDP packet in TORA

Advantages:

(i) This protocol supports multiple routes in shape of pairs between source and destination.

(ii) In case of failure or breakage of node switching to an alternate node is done quickly without creating any intervention in source.

Disadvantages:

1 It creates temporary routes between nodes.

2 Nodes contain synchronized clocks among them

3 TORA algorithm depends on those clocks

2.4 Zone Routing Protocol

ZRP is hybrid type of protocol that combines routing techniques of both reactive and proactive algorithms. In ZRP complete network is divided into zones. Each small part of network is represented by zone and each node of zone maintains its routing table that maintains entry information of all other nodes in its zones.Each node can enter inside the network by defines range (in hops). A routing zone is created by each node. ZRP consist three components.

- Intra zone routing protocol: It maintains information about states for links to any given node those are on short distances.
- Reactive inter zone routing protocol: To determine routes that are on some long distance it uses route discovery protocol.
- Border cost resolution protocol: To deliver packets towards nodes that relay on border of zones it uses uni cast routing.

Inside zone maximum number of hops towards farthest node is represented by zone radius d=2 illustrated in figure 7. Within zone table driven architecture is used by nodes and outside nodes of its zone does not maintain routing information record permanently. Nodes that are within the routing zone can send packets immediately because they have immediate routing available but when they need to send packet outside of zone they will get route on demand basis by using any on demand routing protocol. There are three components used by ZRP protocol within table driven or proactive zone, the routing information is managed by (IARP) Intra zone routing protocol. Implementation of IARP is dependent; either you use distance vector routing or link state routing.

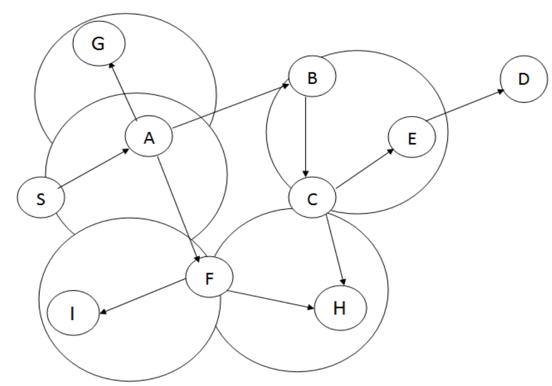

Figure 7: Example of ZRP where S performs route discovery for D with zone radius = 2

(IERP) inter zone routing protocol is used to perform transmissions outside of zone. Within zone routes to nodes are provided by IARP protocol and outside of zone routes are discover by RREQ and RREP packets with the use of IERP protocol [7,8].

Advantages:

(i) When we compare it with table driven protocols, it has reduced amount of overhead during communication and also reduces delays.

(ii) Routes was discovered faster due to association of DSR protocols because to travel outside the zone it needs route and the route will be discover by routing up to boundaries of required destination.

(iii) To the destination routes are maintain by boundary nodes using proactive techniquesnodes of boundaries sends reply back to the source to create route between source and destination by using address of routing.

Drawbacks:

1 Protocol performs transmission using proactive protocols when large values are needed to be used for routing zone, while for smaller values it perform transmissions like reactive protocol.
2 Proactive overhead is limited by ZRP to the zone size only and reactive overhead is also limited by ZRP to choose border nodes only.
3 When through the whole network RREQ packets are started flooding theninefficiency may arise. Better solution is provided by this protocol to some extent in order to reduce overhead and delay during communication but this is beneficial only for zone size and dynamics of zone.
4 When through IERP destination has found then optimized shortest path does not provided by ZRP. As size of network increases, large overheads are created by ZRP periodically. This means every node needs large memory and topological information at high level and extra resources are taken b network as a burden.

2.5 Multimedia support in Mobile Wireless networks:

This protocol maintains the network by using hierarchy of clusters. Two nodes are used by each cluster end points and switches. Location management is performing by Location manager (LM) that each cluster contains. Multimedia support in Mobile Wireless network (MMWN) contains a database that is dynamically distributed and stores all information in it. For user data traffic sources and destination nodes are only can be an end point and routing functions can be perform by switches [7]. When formation of low level partitions are needed in hierarchy, most convenient switches are choose by end points for checking their associatively with other nodes. Cells are organized by grouping end points around those switches called cluster heads. This process is known as “cell information”. Clusters are formed hierarchically by switches and each of cluster functions as multi hop packet radio network. Keeping track of hierarchical addresses is important to support transfer of data between mobile nodes. When changes in hierarchical addresses occur due to mobility, location manager uses both paging and query/response in conjunction. Every cluster contains its own LM that controls all the nodes within network and outside of cluster. With respect to clustering hierarchy each node has a roaming level. Within roaming cluster paging technique is used to locate mobile nodes. When mobility of nodes occurs and node moves outside of current roaming cluster, update about location is transferred to LM [16].

This scheme contains several features whose implementation is complex.

i. Location manager is connected with hierarchical topology of network. Location finding and location updating becomes complex due to this feature. Through Location managers hierarchical tree, location updating/finding has to travel. Due to changing in location managers hierarchical cluster membership, reconstruction in location management tree occurs.
ii. For routing and addressing MMWN provides its own routing protocols. It is not based on IP standard protocol. To enable internetwork of MMWN encapsulated interface translation capabilities is needed with IP networks [16].

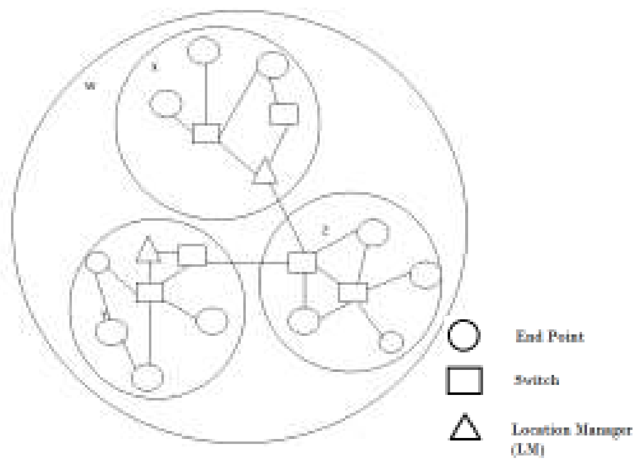

Figure 8: Example of Clustering Hierarchy in MMWN

Benefits are when we compare this algorithm with other traditional table driven architectures it reduces routing overhead due to use of LM because LM performs all functions of location finding and location updating. Location finding and updating functions are very difficult due to networks hierarchical structure and LM is very near to it. In order to perform location finding and updating it needs to travel massages through LMs hierarchical tree and membership of LMs in hierarchical tree changes makes consistency management very difficult and also effects hierarchical tree of management. Problems are created due to that are difficult to solve [7].

2.6 Destination Sequenced Distance Vector:

DSDV maintains view of the network continuously or DSDV keeps in view whole network consistently by maintaining routing tables. Routing tables contain routing information received by periodic update of routing. Every node contains routing table storing routing information in it. New route broadcast contain destination address, no: of hops required to reach destination, destination sequence no: & for new broadcast a new sequence no:. A fresh route is that receives currently new sequence no: and sequence no: of two routes are suppose to be same than by considering better metric new route will be selected. DSDV uses distance vector shortest path routing algorithm that creates a single link towards the destination. It uses two type of packet updates in order to minimize amount of overhead. First one is full dump packet to carry routing information that is available. Second is incremental packet that carries current information only (changed since last full dump) as compare to full dump packets more amount of incremental packets are sent.

Regardless of network traffic DSDV needs to transmit update packets about routing table periodically so it still has large amount of overhead and according to O(N2) overhead grows. Due to scalability of network more bandwidth and more size of routing tables are required. DSDV is not efficient in large networks because when network topology change occurs routing loops can occur.

In case of link failure and addition of nodes setting time is complex to determine. Multipath routing is not supported by DSDV. In terms of routing overhead DSDV is good to perform tested by different simulation environments but because it cannot detect link breakages fastly so more packets of data are dropped. In case of security issue DSDV specifications are silent. DSDV trust all nodes and assume them as cooperative but once attacker creates a false sequence, it sends new packets consistently to update the value so huge part of network nodes will be cheated and du to misbehaving of single host node entire network can be effect by serious threats [7,8]. Figure 9 illustrates the working of DSDV protocol.

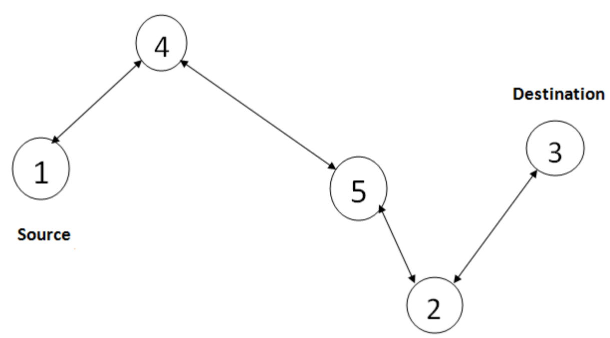

Figure 9: Example of DSDV

In DSDV each node of network maintains a routing table that contains addressing information of every other node in the network. In order to reach destination node each node of network contains address of next hop node along with its address in routing table. Figure shows bi directional connection of DSDV network where node 1 is source and node 3 is destination. Node 1 transmits packet for further forwarding to node 4. Node 4 will look for address of destination in its routing table. Node 4 then takes next hop to transmit packet towards node 5 in this case. This procedure is repeated consistently until packet reaches to its required destination.

2.7 Wireless Routing Protocol:

Same as DSDV all nodes maintain routing information among them. Four tables are maintaining by each node namely Distance table, Routing table, Link cost table and Message retransmission list (MRL) table. MRL contains update massage sequence number, a transmission counter, a flag vector required by acknowledgment (by vector neighbor entry) and update list of every update massage in its each entry. MRL takes all information about massages that are needed to be transmitted and transmission acknowledgment given by which neighbors is recorded in update massages.

WRP needs huge amount of memory to maintain four tables as compare to other proactive routing protocols. It creates link between nodes by sending hello messages. Hello messages are broadcasted when network nodes are free from transmission so each node needs to remain active every time. Nodes cannot enter in idle condition to save their battery power because it maintains separate tables so it has less latency as compare to others. Underlying routing protocols used by WRP is distance vector shortest path routing and their addition and link failure, it is complex to manage. During broadcasting message WRP focuses on near vicinity and even in their vicinity neighbor nodes may not have complete information is concluded by WRP so there is a limit of transmission of data in small regions. To neighbor nodes they have limited update messages. This limit is not for close vicinity but for network view of nodes [8].

3. PERFORMANCE METRICS:

Performance of adhoc routing protocols is compare by taking following qualitative and quantitative metrics in consideration.

(i) Routing Overhead: To Broadcast/propagate data packets for route discovery and route maintenance how many packets need to be sent. Due to location changing in network by nodes, unnecessary routing overhead occurs because in routing table the generation of stale routes occurs.

(ii) Throughput: it is the ratio between amounts of total packets sends by sender to receiver and what amount of time receiver takes to receive last packet. It is measured in Bits per second (bps). Throughput is one of the main parameter of MANETs network that provides capacity of channel that is use full for transmission. It performs selection of destination node at the start of simulation and gives information about data is delivered to destination correctly or not.

(iii) Packet Delivery Ratio: it is the ratio between total amount of packets incoming through channel and data packets those are received successfully.Loss rate will be described and seen at transport protocols that effects network supported maximum delay. When load of network and no of packets are less, DSR performs very well. Performance of DSR is effected by increase of nodes in network in other words due to increased network traffic. AODV performance remains same continuously while DSDV performs better as compare to other two protocols.

(iv) End to end delay: it is defined as how much time packet takes to be transmitted from source to destinations application layer. It is measured in seconds. Delays those occur due to queue in transmission of data packets and route discovery process are also included in end to end delay.CBR packets high rate effects delay. Buffers become more faster because before transmission packets need to be stored in buffers for long time. This is seen during research that AODV and DSR performance in terms of average end to end delay is same almost. But due to increase in no: of nodes routing tables load exchange also increases so the DSDV performance degrades and increase in frequency of exchange also occurs due to nodes mobility.

(v) Energy variance of node: calculation of total amount of distributed energy among nodes.

(vi) Remaining battery power: this metric calculates remaining average battery power remaining and total no: of nodes in the network. In adhoc network every node is operated on power of battery and rare resource is energy of battery. Performance of protocols is analyzed in terms of power through this metric.

(vii) Consumed power: this metric considers average of consumed batter power v/s no: of nodes in network.Energy consumption also occurs during hearing process not only during transmission and reception of data.

(viii) **Retransmission:** no of packets that are retransmitted because of packet loss. when sender sends data packet to destination it retains a copy of packet until it receives acknowledgment from receiver that it has receives the packet correctly. Sender performs retransmission in different circumferences. Reasons for retransmission are:

1 If time exceeds and no acknowledgment found at sender.
2 When sender observes about unsuccessful transmission.
3 When sender gets notice from receiver that expected data is not received.
4 When data packet is received by receiver but not correctly then notifies to sender about correctness.

(ix) **No: of dropped packets:** amount of packets that are failed to be reach at destination during transmission is known as packet drop. This metric calculates no: of dropped packets vs. time. Due to completion of TTL (time to live) dropping of packets occurs. Life time of packets depends upon protocol. Packets became dropped when protocol takes too much time to decide path towards destination. Routing directions can be find by efficient protocols then rate of dropped packets reduces. The dropped packets for DSR are less than that of DSDV.

4. DISCUSSION / COMPARATIVE STUDY

Our main objectives were minimizing network throughput, maximizing lifetime of network and minimizing delay during transmission and hearing for channel. This paper evaluated the comparative study and performance of DSR, AODV, TORA, DSDV, WRP and MMWN on basis of energy efficiency, throughput, routing overhead, end to end delay and no: of packets dropped. We have concluded that inefficient performance was given by TORA protocol. In small networks, no any significant differences reveal by throughput and energy consumption. In small network sizes DSR,DSDV and AODV performance was comparable but in large networks good results are only produce by AODV and DSR. While in all scenarios in terms of throughput AODV performance was overall good. In terms of energy consumption performance of AODV and DSR was comparable while TORA, DSDV and ZRP consume more power but dropped packet ratio was maximum in AODV as compare to other routing protocols.

The following table illustrates the routing protocols comparison in terms metrics discussed in section 3.

5. CONCLUSION

In this paper, we have described working of several proposed routing schemes. According to routing strategy, we have classified these schemes on basis of table driven, On–demand and hybrid type of routing algorithms. We have compared these three categories of routing algorithms highlighted their characteristics, differences, features, benefits and their drawbacks. Mobile networking (MANET) field is expandable and changes day by day. Still some of the routing protocols working management and problem are too much complex to solve as to write new protocol. Bandwidth constraints and limited power of mobile devices are most prominent issues in MANET. Security and power awareness is hard to achieve due to dynamically changing topology. These issues are handled by some schemes that are mentioned above. Therefore a better routing solution is needed that also address other issues related to routing. Our future work is the focus on the study of these issues and for MANET routing protocols we will take effort to propose the solution for power awareness and secure routing.

Routing Protocols	Performance Metrics									
	Routing Overhead	End to End Delay	Throughput	Packet Retransmitted	Energy Consumption					Dropped Packet
					Consumed Power	Remaining Battery	Tx	Rx	Routing	
AODV	High	Medium	Medium	High	Low	High	M	H	M	High
DSR	Medium	High	Low	Low	Low	High	M	H	L	Low
TORA	Medium	H.L	L,H	High	High	Low	H	H	H	_
DSDV	High	Low	Medium	_	Stable	Low	M	H	M	High
ZRP	_	Medium	Low	_	High	Low	H	H	H	Medium

Table 1: Comparison of the routing protocols with respect to the performance metrics

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