PANORAMA OF REACTIVE ADHOC ROUTING PROTOCOLS TO ENERGY RICHNESS AND SCALABILITY SUPPORT

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ABSTRACT

Mobile ad hoc network (MANET) is a self-governing system of mobile nodes connected by wireless links. Each node operates not only as a host, but also as a router. The nodes are free to move about and organize themselves into a network. The dynamic topology of MANETs and its limited finite resources makes the task of routing very cumbersome in MANETs. Therefore, these finite resources (like energy) should be well used with the aim of improving the overall routing and network performance. Continuous routing improvements can speed up the working efficiency of MANETs. Routing protocols especially in emergency situations must be energy efficient and scalable.

This paper is an attempt to check the acceptability of a sensible base routing protocol on the basis of energy richness and scalability support. In this paper, a comparative analysis of four reactive routing protocols namely AODV, AOMDV, DSRand CBRP is done. Here CBRP is also a hierarchical routing protocol. This paper is aimed to analyze the adequacy of considered routing protocols in an energy constrained environment under varying mobility and pause time. These protocols have been analyzed extensively for various performance parameters (energy consumption, delay, throughput, Packet Delivery Ratio etc.) over different network scenarios. Simulation results show that none of the protocol surpasses other for all considered scenarios. However, CBRP has produced better results in terms of throughput, normalized routing load and delay while AOMDV is a better choice for energy related parameters. Simulation results of the paper are very helpful for the wise selection of the energy efficient base routing approach to scale MANETs.

Keywords: Adhoc Networks, AODV, AOMDV, CBRP, DSR, Energy, Routing,

I. INTRODUCTION

Mobile ad-hoc network (MANETs) [1-2]are independent, self-organized, decentralized and self-configurable wireless networks where the mobile nodes are free to move about and organize themselves into a Mobile ad-hoc networks can turn the dream of getting connected "anywhere and at any time" into reality. In MANET each node act as a host as well as a router .The application of MANET is widespread in commercial, military, and disaster relief effort. In MANET, all the nodes are mobile nodes and the topology will be changed rapidly.

Routes in ad hoc networks are multihop because of the limited propagation range of wireless nodes. Since nodes in the network move freely and randomly, routes often get disconnected. Routing protocols are thus responsible for maintaining and reconstructing the routes in a timely manner as well as establishing the durable routes.

Routing protocols proposed for mobile ad hoc wireless networks can generally be classified in to three different categories namely proactive, reactive and hierarchical [26].

It is clear from the literature that reactive protocols are better than the proactive protocols [23-25] especially in terms of delay and overheads under fluid dynamic and energy constrained environment of MANETs. Hence, four reactive protocols namely AODV, AOMDV, DSR and CBRP which is also a hierarchical protocol are considered for performance evaluation over different network scenarios.

The work done in this paper suggests that for the initial design of an efficient routing protocol, existing base protocols need to be modified. Such protocols must be energy rich to provide long lived routes to make routing easier as battery is the most critical resource in MANETs. Therefore, this work concentrates on checking the performance of many reactive protocols in terms of energy richness for large network size.

II. RELATED WORK

A lot of work to evaluate the performance of proactive and reactive protocols has been already done by various authors. P. Johansson et al [3], compare DSDV, AODV, DSR over existence scenarios, varying node mobility and traffic load .They focus on (a) packet loss (b) delay (c) routing overhead and (d) throughput introducing mobility events in term of relative speed of nodes instead than absolute one. For the lower load DSR performance is better and for the higher load AODV is much better. Mukesh Kumar et al [4] checked the performance of DSR, AODV, and CBRP on the basis of CBR traffic. They compared the protocols in terms of (a) Packet delivery ratio (b) Average routing overhead (c) Average end to end delay with variation in pause time and varying no of nodes. This paper concludes that cluster structure is more scalable and route efficient as network size increase. Awadesh Kumar et al [5] compare the performance of AODV, DSDV, CBRP, and DSR with network size of 5 nodes only. .The routing protocol were compared in terms of (a)Packet delivery ratio (b)Throughput (c)Average throughput (d)Average delay (e)Minimum and Maximum delay with variation in network mobility. This paper conclude that AODV performance is better than DSR,DSDV,CBRP in terms of throughput and average delay while CBRP is better in terms of packet delivery ratio. They conclude that AODV protocol is better after analyzing all the parameters.S. R .Das et al [6] compare the performance of two routing protocol (AODV and DSR) in terms of (a) Packet loss (b)routing load (c) end to end delay. Main suggestions include (i) use time to live fields into the network places (ii) the importance of interaction layers when designing new protocol (iii) take into account congestion metrics in order to calculate the new route. Biradar et al [7] compared the performance of AOMDV and AODV in terms of (i)Packet delivery fraction (ii)end to end delay and routing overhead. Result of the paper shows that protocol behaves differently for different parameters. Macro et al [8] evaluated the energy aware behavior of proactive and reactive routing protocol.Results of the paper suggest that reactive protocols work well in less traffic load while proactive works well in case of higer traffic offered to the network. Shivalal et al [9] evaluated the performance of AODV and DSR routing protocol for Ad hoc network for (a) packet delivery fraction (b) throughput. They conclude that DSR perform better for packet delivery fraction and throughput than AODV.They concluded with an increase in number of nodes for a fixed area of 500m x500m even if the network scenario is kept constant the behavior of these two routing protocol changes. Hence they conclude that overall performance of DSR is better than AODV for the performance metrics with varying number of nodes. Priyanka et al [10] compares the different routing protocol such as AODV, TORA, DYMO, and AOMDV routing protocol under different network conditions. They measure performance metrics such as (a) Packet delivery ratio (b) Throughput (c) End to end delay .They conclude that AOMDV performs better under different network conditions. Mohammed A. Mahdi and Tat Chee Wan [11] compare the performance of CBRP, AODV and DSR routing protocol in dense and sparse topology. The performance metrics are (a) packet delivery ratio (b) normalized routing load(c) delay. They conclude that in Dense topology (1000x1000 m^2) the CBRP performance is better than AODV and DSR for the performance metrics packet delivery ratio, normalized routing load when traffic source exceed 20 sources and for the performance metric delay, AODV performance is better than CBRP and DSR .AODV has the lowest delay. In Sparse topology (1500x1500 m^2) CBRP performance is better than AODV and DSR for the normalized routing load when traffic source exceed 20 sources while AODV performance is better than other two protocols with traffic source 30 and 40.They also conclude that for the traffic source (10,30 and 40)AODV performance is better than CBRP and DSR .They also concluded that for both dense and sparse topology as the node speed increases the performance of these three protocol decreased. Ravindra Eklalkar et al. [12] evaluated AODV, DSR, and CBRP and modified for the performance metric (a) packet delivery fraction (b) average end to end delay (c) normalized routing load. They conclude for the packet delivery ratio that CBRP is better than DSR. Modified CBRP shows off better than AODV.Cluster based routing gives reduced overhead compare to flat routing number of nodes involved in flooding of route request packet are minimized. AODV has less average end-to end delay.

III. DESCRIPTIONOF STUDIED ROUTING PROTOCOLS

AODV, DSR, CBRP and AOMDV are the routing protocols that have been analyzed on the anvil ofsome traditional and energy parameters. The following section discusses the working of these protocols.

3.1 Adhoc On Demand Distance Vector Routing (AODV)

AODV is a reactive unicast routing protocol for MANETs [13].As a reactive routing protocol [14], AODV only needs to maintain the routing information about the active paths.In AODV, the routing information is maintained in the routing tables at all the nodes.

A source node uses a route request (RREQ) and a route reply (RREP) [15] message to setup a route between a source and a destination. At the end of the route discovery process, packets can be delivered from the source to the destination node. If the link breaks nodes broadcast a route error message to the source node to inform about the inaccessible destination. After receiving the (RERR), the source node can start again the route discovery by using the sequence number to guarantee the freshness of routes.

3.2 Dynamic Source Routing (DSR)

DSR [16] is another popular on demand routing protocol, in which routing take place in two phases: route discovery and route maintenance. The key distinguishing features of DSR is the use of source routing.During the first phase that is route discovery the sender node floods the network with route request (RREQ) packets. Each node receiving the RREQ packets ,rebroadcast it, unless it reaches to the destination or it find a route to the destination in its route cache .Such kind of nodes which find either destination or route to the destination will send(RREP) packet to the original source node . The RREP routes itself back to the source by traversing this path backward. The route carried back by the RREP packet is cached at the source for future use.

If any link on a source route is broken, the source node is notified using a route error (RERR) packet. The source removes any route using this link from its cache. A new route discovery process must be initiated by the source if this route is still needed. DSR makes very aggressive use of source routing and route caching.

3.3 Cluster Based Routing Protocol (CBRP)

CBRP[18] is a hierarchical on-demand routing protocol that uses source routing, similar to DSR, to avoid forming loops and route packets The goal of clustering is to group the mobile nodes in 'Clusters' in order to organize the nodes in form of a hierarchy, so that significant improvement can be made in the network performance, specifically with large number of nodes. CBRP [16][17] is a pioneer clustering protocol. It consist of two main parts: Clustering Algorithm and Routing Algorithm.

In CBRP, the protocol divides the nodes of the network into a number of overlapping or disjoint 2-hop-diameter clusters in a distributed manner. Each cluster selects one node as a cluster head which coordinates data transmission within the cluster and with other clusters.. These cluster head node are responsible for the routing process. Other node in a cluster can have a role of cluster gateway or simply a cluster member.

The advantage of CBRP is that only cluster heads exchange routing information, therefore thenumber of control overhead transmitted through the network is far less than the traditional flooding methods.

As a summary, the CBRP has many features [18]. It is fully distributed in operation with less flooding traffic during the dynamic route discovery process.Broken routes in CBRP could be repaired locally without rediscovery.

3.4 Ad hoc On-Demand Multipath Distance Vector Routing

AOMDV [19] [20] on the other hand is a multi-path routing protocol. It is an extension to AODV and also provides two main services i.e. route discovery and maintenance. Unlike AODV [21], every RREP is being considered by the source node and thus multiple paths discovered in one route discovery. Being the hop-by-hop routing protocol, the intermediate node maintains multiple path entries in their respective routing table. An alternate path to the destination is accepted by a node if the hop count is less than the advertised hop count for the destination.

IV. SIMULATION ENVIRONMENT AND RESULTS

The Network simulator NS-2 has been used to observe the energy behavior for AODV, DSR, CBRP, AOMDV protocols with respect to the mobility of the nodes and pause time. Different Simulation parameters which are being used for a 100 node network over AODV, DSR, CBRP and AOMDV protocols are shown in Table 1.

Table 1: Simulation Parameters

Simulation Area	$1000 \times 1000\ m^2$
Protocols used	AODV ,DSR , CBRP and AOMDV
power consumption for Transmission	1.6 W
power consumption for Reception	1.2 W
Speed of nodes	1 m/sec to 20 m/sec
Network size	100

Energy supplied to each Node	100 joules
Mobility Model	RWP
Data Rate	2 Mbps
Transmission Range	250 mtr
Traffic Source	CBR
Packet size	512 byte

The results of the simulations performed on AODV, AOMDV, DSR and CBRP,when the network consists of CBR traffic sources are presented in this section. The comparison of these protocols with respect to varying speed of the mobile nodes and pause time for different performance metrics are discussed andshown below.

4.1 Total Energy Consumed

Total energy consumed is the sum of the energy dissipated by all the nodes after each simulation run.

Fig. 1 shows the energy consumption behavior of AODV, DSR, CBRP and AOMDV protocols with varying speed from 5-20 m/sec. It is observed that, AODV consumes lesser energy in varying mobility scenario compared to DSR and CBRP. But AOMDV consumes lesser energy as compare to other considered protocols when speed increases. DSR performance is worst. Thus AOMDV is a better protocol in terms of energy consumption in varying mobility scenario.

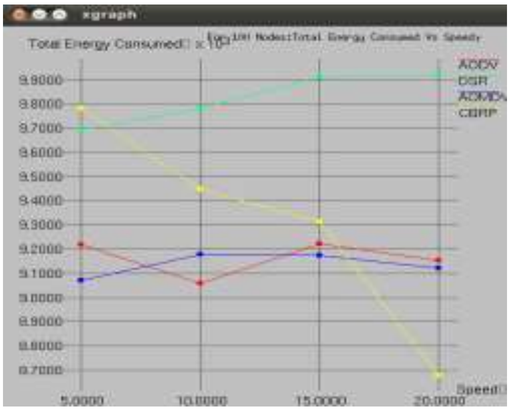

Fig 1: Total Energy Consumption Against Different Speeds of the Nodes

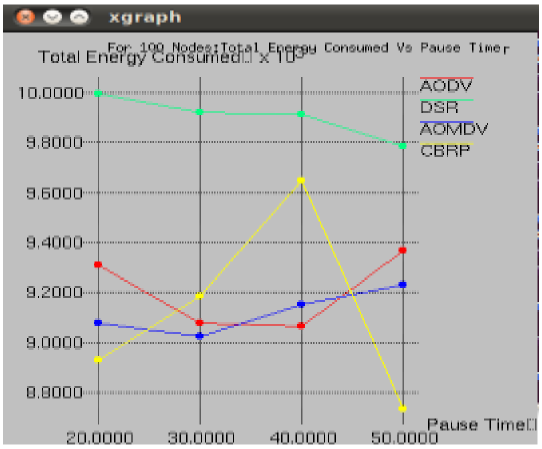

Fig 2: Total Energy Consumption Against Different Pause Time

Fig. 2 shows the energy consumption behavior of AODV, DSR, CBRP and AOMDV protocols with varying pause time. It is observed that, AODV consumes lesser energy compared to DSR, CBRP but AOMDV again consuming lesser energy as the pause time increasing. DSR performance is worst. Thus AOMDV is a better protocol in terms of energy consumption in terms of varying pause time also.

4.2 Average Energy Consumed

Average energy consumed is the energy obtained at each alive node to the number of alive nodes after each simulation run.

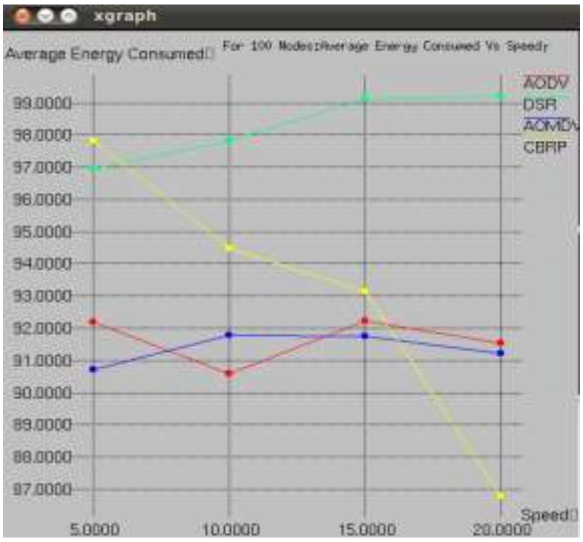

Fig 3: Average Energy Consumed Against Different Speeds of the Nodes

Fig. 3shows the Average energy consumption behavior of AODV, DSR, CBRP and AOMDV protocols with varying speed. It is observed that, average energy consumed by AODV is lesser as compared to DSR and CBRP but again AOMDV in comparison to AODV is consuming lesser energy as speed increases. DSR performance is worst. Thus AOMDV, is a better protocol in terms of average energy consumed under varying mobility scenario.

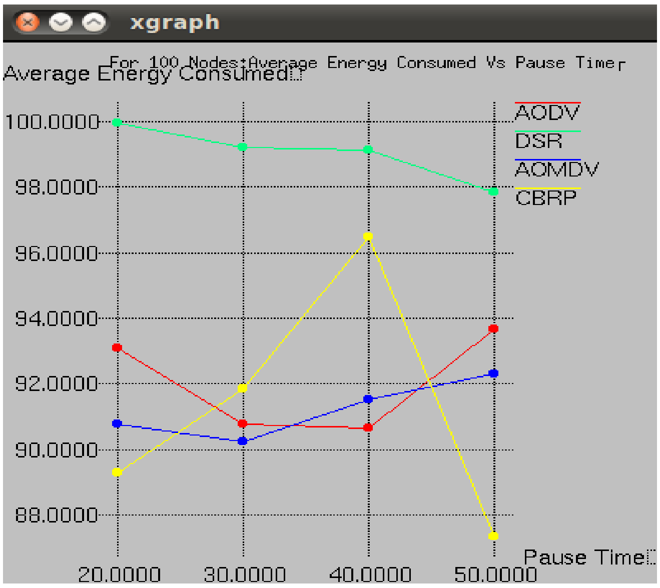

Fig 4: Average Energy Consumed Against Different Pause Time

Fig. 4 shows the Average energy consumption behavior of AODV, DSR, CBRP and AOMDV protocols with varying pause time. It is observed that, AODV consumes lesser energy compared to DSR and CBRP but AOMDV in comparison to AODV is again consuming lesser energy as the pause time is increasing. DSR performance is worst. Thus AOMDV is a better protocol in terms of average energy consumed in terms of varying pause time.

4.3Total Delay

Delay is defined as the total latency experienced by a packet to traverse the network from the source to destination. It is calculated as:

Total Delay = (Tr –Ts)

Where Tr is receive Time and Ts is sent Time.

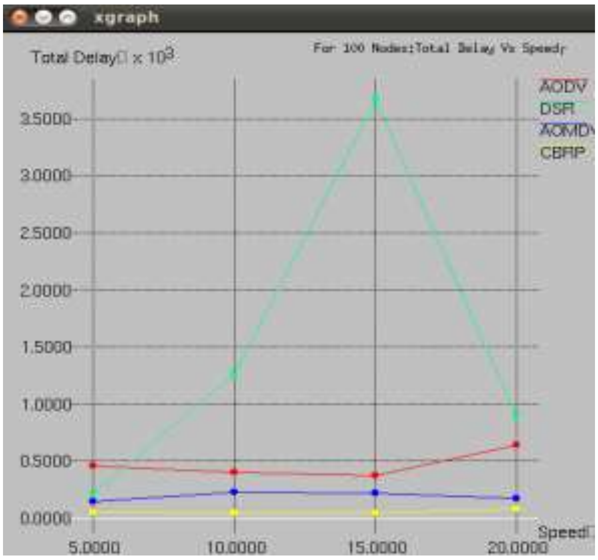

Fig 5: Total Delay Against Different Speed of the Nodes

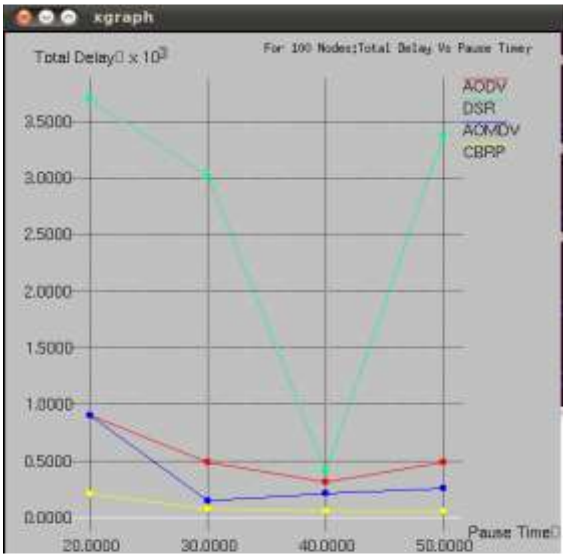

Fig 6: Total Delay Against Different Pause Time

Fig. 5 shows that Total delay of AODV, DSR, CBRP and AOMDV protocols with varying speed. It is observed that total delay of CBRP is least as compare to AODV, AOMDV and DSR. DSR performance is worst. Thus, CBRP is a better protocol in terms of total delay for varying mobility scenario.

Fig. 6 shows that total delay of AODV, DSR, CBRP and AOMDV protocols with varying pause time. It is observed that total delay of CBRP is again least as compare to AODV, AOMDV and DSR. DSR performance is worst.

4.4 Average Delay

The average end-to-end delay of data packets is the interval between the data packet generation time and the time when the last bit arrives at the destination. It is calculated as following:

$$\frac{\sum_1^n \mathbf{CBRsent_{time}} - \mathbf{CBR\ receiver_{time}}}{\sum_1^n \mathbf{CBR_{Received}}}$$

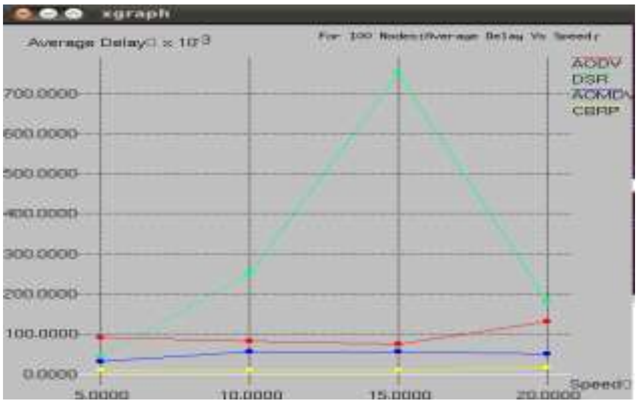

Fig 7: Average Delay Against Different Speeds of the Nodes

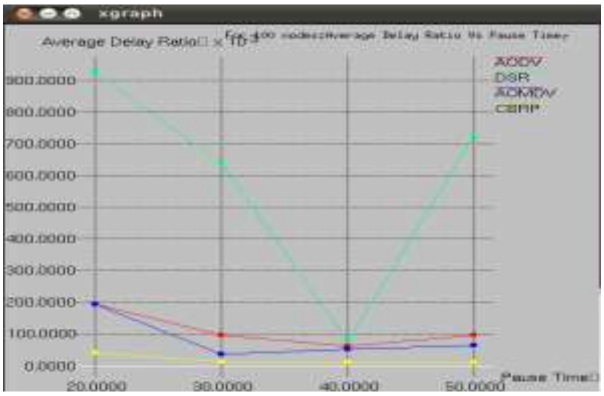

Fig 8: Average Delay Against Different Pause Time

Fig. 7 shows the Average delay of AODV, DSR, CBRP and AOMDV protocols with varying speed. It is observed that Average delay of CBRP is least as compare to AODV,AOMDV and DSR. DSR performance is worst .Thus, CBRP is a better protocol in terms of Average delay for varying mobility scenario.

Fig. 8 shows the Average delay of AODV, DSR, CBRP and AOMDV protocols with varying pause time.It is observed that Average delay of CBRP is again least as compare to AODV, AOMDV and DSR. DSR performance is worst .Thus, CBRP is a better protocol in terms of Average delay of varying pause time.

4.5 Throughput

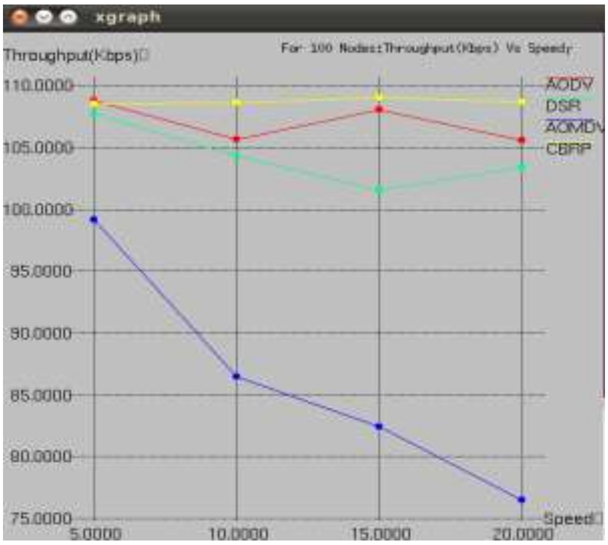

Fig 9: Throughput Against Different Speeds of the Nodes

It is defined as the total number of packets delivered over the total simulation time. Mathematically it is defined as:

$$\frac{\text{Receiver Byte} * 8/(\text{End time} - \text{Start Time})}{100}$$

Fig. 9 shows the throughput of AODV, DSR, CBRP and AOMDV protocol with varying speed. It is observed that throughput of CBRP is highest among all considered protocols. AOMDV performance is worst in all, as the speed increasing throughput is decreasing. Thus, CBRP is a better protocol in terms of throughput for varying mobility scenario.

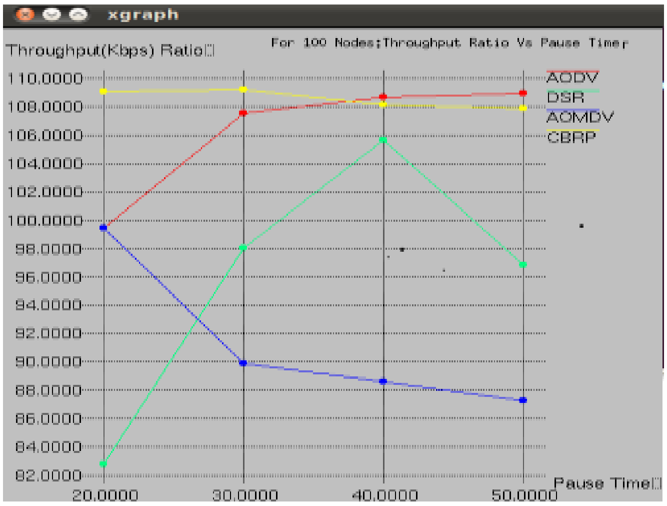

Fig 10: Throughput Against Different Pause Time

Throughput of AODV, DSR, CBRP and AOMDV protocol with varying pause time is shown in Fig. 10.It can be seen that throughput of CBRP is again higher than other protocols. AOMDV performance is worst in all, as the pause time is increasing throughput is decreasing. Thus, CBRP is a better protocol in terms of throughput with varying pause time.

4.6 Packet Delivery Ratio (PDR)

The ratio of the data packets delivered to the destinations to those generated by the CBR sources. It is calculated as:

$$\frac{\text{Number Of Received Packet} * 100}{\text{Number Of Sent Packet}}$$

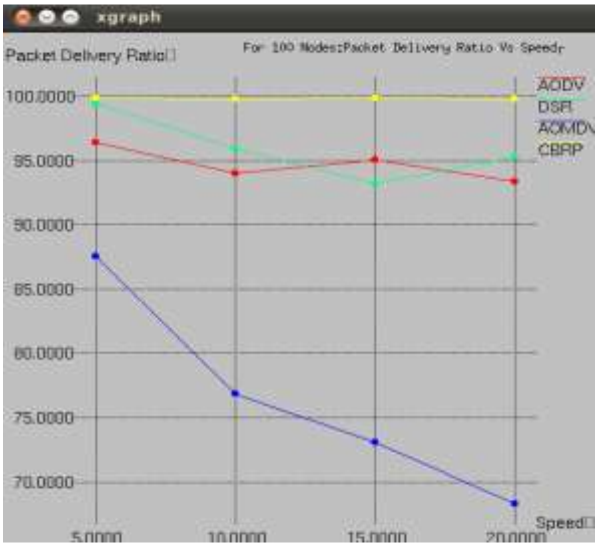

Fig 11: Packet Delivery Ratio Against Different Speeds of the Nodes

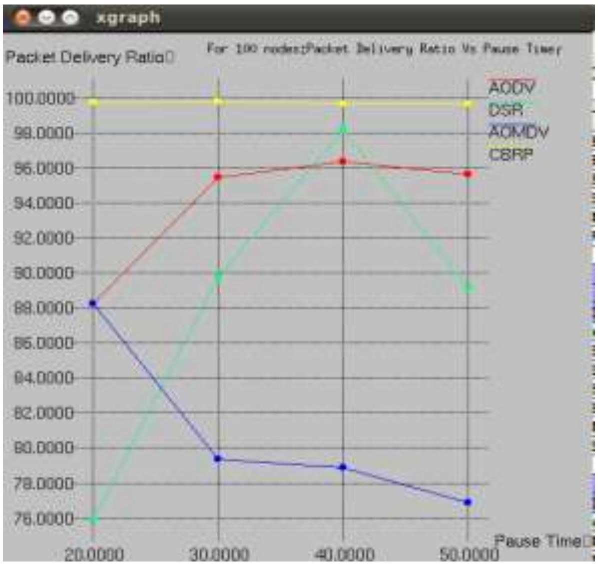

Fig 12: Packet Delivery Ratio Against Different Pause Time

Fig. 11 shows that Packet Delivery Ratio of AODV, DSR ,CBRP and AOMDV protocol with varying speed .It is observed that that Packet Delivery Ratio of CBRP are highest in comparison to AODV, AOMDV .AOMDV performance is worst in all, as the speed is increasing Packet delivery ratio is decreasing. . Thus CBRP is abetter protocol in terms of packet delivery ratio with varying mobility scenario.

Fig. 12 shows the Packet Delivery Ratio of AODV, DSR, CBRP and AOMDV protocol with varying pause time.It is observed that PDR of CBRP is higheras compare to other protocols .AOMDV performance is worst in all, as the pause time is increasing PDR is decreasing. Thus, CBRP is a better protocol in terms of packet delivery ratio with varying pause time.

V. CONCLUSION AND FUTURE WORK

In this paper, the energy efficiency of some well accepted reactive (on demand) MANET routing protocols with respect to varying mobility and pause time is benchmarked.Flat routing (on-demand) protocols allow deploying large networks in the expense of routing overheads and latency. For scaling the network, hierarchical routing can be deployed using clustering algorithms. Mobility and dynamic hierarchy, however, need to be carefully taken into account in order to achieve any practical solutions.

In this work, when the four protocols were analyzed on the anvil of different performance parameters (especially over energy and large network size), it was observed that the overall performance of the protocols also depends upon the mobility and traffic conditions, since it reflects reaction of routing protocol during link failures and route maintenance.

Although none of the considered protocol is a clear winner for all considered network situations but yet the overall performance of CBRP protocols is much better than other three flat routing protocols in term of throughput, packet delivery ratio, average delay and total delay as far as the size of the network is considered. For the additional parameters such as average and total energy consumption the performance of AOMDV is much better than other routing protocols.

The analytical study in this paper suggests that CBRP can be used whenever better traditional parameters are to be achieved by any routing strategy. While, AOMDV can be preferred if energy efficiency is the prime concern for the longer network lifetime. However, this study is limited in network size. Therefore, in future more rigorous analysis is required over the considered routing protocols for much larger size of the network along with varying traffic load. This can help to design an efficient routing protocol in terms of energy richness and scalability support to MANETs.

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