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Performance Evaluation of DHT Based multi-path Routing Protocol for MANETs

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Abstract- Mobile Adhoc Networks (MANETs) creates a temporary network of mobile nodes. Routing is a major issue in MANETs. Distributed Hash Tables (DHTs) has recently proven to be a novel and efficient way for developing scalable routing protocols in MANETs. With the increase in applications of MANETS, the networks have become very complex which leads to channel impairments. Moreover multipath protocols provide fault tolerance against node and link failures. In this paper, we have analyzed the performance of M-DART[4], which is DHT based Multipath protocol against Ad hoc On-Demand Multipath Distance Vector Routing Protocol(AOMDV)[7] ,which is a reactive Multipath protocol. We have conducted various simulation experiments to evaluate its performance in terms of throughput, packet delivery ratio, end to end delay and energy consumption. We have analyzed that M-DART protocol consumes less energy (8.2% than AOMDV. Simulation results also show M-DART has better throughput and Packet Delivery ratio than AOMDV by more than 1.6 times.

Index Terms- AOMDV, M-DART, Multipath Protocols, ad-hoc Network, MANET.

I. INTRODUCTION

Mobile Ad hoc network represents complex distributed systems comprised by wireless nodes which can freely and dynamically self-organize themselves into temporary (ad hoc) network topologies. In this way MANETs allow communications in areas with no pre-existing infrastructure. The ad hoc network paradigm has been proposed several years ago mainly for tactical networks. Recently, the introduction of enabling technologies, such as Bluetooth and Wi-Fi, has led to the deployment of commercial ad hoc networks outside the military domain, generating so a new and growing interest in the research and development of such networks. Researchers visualize MANETs to be an integral part of 4G architecture and in the next generation networks [1]. MANETs consist of rapidly changing network topology as nodes move in a random manner. They can work either standalone or may be connected to a larger internet. Because of the absence of fixed infrastructure, nodes setup routes among themselves autonomously. Nodes in a MANET (laptops, PDAs, and so on) move arbitrarily and communicate directly with other nodes sharing the identical media (radio, infrared, etc.) within their radio transmission range. Outside this range, message transfer occurs through hop-by-hop communication. Routing packets between pair of nodes becomes a challenging task due to random motion of nodes within the network. A route that is believed to be optimal at a given point in time might not work at all a few moments later.

Table Driven routing protocols [2],[3],[4] as shown in Figure 1 also called proactive protocols maintain table containing routes to all nodes. They react to any change in the topology even if no traffic is affected by the change, and they transfer periodic control messages to maintain routes to every node in the network. As mobility increases, proactive protocols require more scarce resources, such as bandwidth and power.

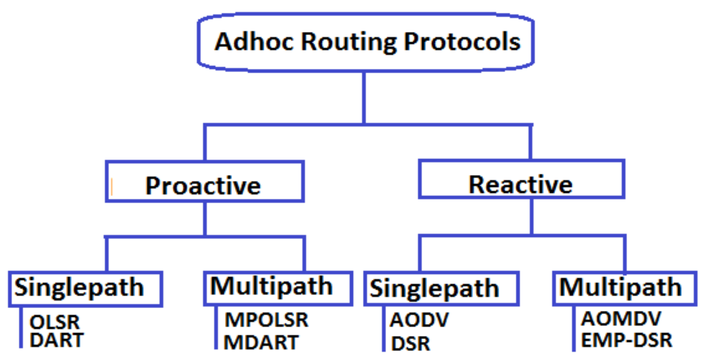

Figure 1: Types of Routing Protocols

Reactive routing protocols [5],[6],[7] determine the route only when they need to route packets, thus avoiding nodes from periodical transfer of route update in the network.

The behaviour of routing protocols depends on the link capacity, network size, and node mobility. The topological instability (link and node failures) due to node mobility and/or changes in wireless transmission conditions can frequently give rise to disconnected routes. An attractive approach to gain tolerance against unreliable wireless links and node mobility is based on multi-path routing. Multipath routing protocols [4],[7] discover multiple routes from source to destination.

The most popular on-demand routing protocol, Ad-hoc On-demand Multipath Distance Vector (AOMDV) routing protocol [7] is an improvement of Ad-hoc On-demand Routing Protocol (AODV). AOMDV discovers multiple paths between a source and destination to provide efficient fault tolerance by providing quicker and more efficient recovery from route failures in a dynamic network. As AOMDV discovering multiple paths in a single route discovery attempt, new route needs to be discovered only when all paths fail. This reduces not merely the route discovery latency but the routing overheads also.

Most of the protocols, regardless of the belonging class (reactive or proactive, single-path or multi-path), do not have scalability to work efficiently when the number of nodes grows mainly because they have been proposed for wired networks and modified to work in ad hoc scenarios [8]. More specifically, they use static addressing in which the node identity equals routing address. Static addressing is not very valid in ad hoc scenarios. In recent times, some routing protocols [11], [13], [14], [15], [16] have exploited the idea of decoupling node identification from its location by using DHT services, which are used to distribute the location information of node throughout the network. But these protocols are single path so they are not tolerant against channel impairments (node and link failures.

A multipath enhancement to DART [11] was proposed in [12] called Augmented Tree based Routing (ATR), but in ATR the DHT system is replaced by a global lookup table which is available to all the nodes, which results in a great impact on the address discovery, which is a key process of the whole routing protocol. Among the DHT based Routing Protocols, M-DART is an enhancement of shortest path routing protocol known as Dynamic Address Routing (DART) [11]. M-DART discovers and stores multiple paths to the destination in the routing table.

The remainder of this paper is organized as follows. Section II discusses Dynamic Addressing and Dynamic Hash Table (DHT). Section III discusses M-DART and AOMDV routing protocols. Section IV discusses the simulation results of the two routing protocols with different parameters. Finally, we summarize and conclude our paper in section V.

II. DYNAMIC ADDRESSING AND DHT – OVERVIEW

Dynamic Addressing [9] separates the routing address and the identity of a node. The routing address of a node is dynamic and changes with movement of the node to reflect the node's location in the network topology. The identifier is a globally unique number that stays the same during the lifetime of the node. Now the problem arises how to provide mapping between node identity and routing address. In fixed networks, location information can be easily embedded into the topological-dependent node address, which also uniquely identifies the node in the network. But in self-organizing networks, however, there is no permanent relationship between the location of the node and the node’s identifier as a consequence of the spontaneity and adaptability of the network. So, this requires a dynamic association between identification and location of a node, and the specification of a mechanism to manage this association.

In response to these needs, DHTs [10] have been adopted as a scalable substrate to provide many functionalities including distribution of information, location service, and location-independent identity upon which a range of self-organizing systems have been built. The functionality of decoupling identification from location, and of providing a general mapping between them, has made the DHT as an interesting principle to be incorporated in network-level routing protocols. The key idea of DHT is to use a hash function to distribute Node’s location information among rendezvous points throughout the network. This hash function is also used by a source to identify the point that stores a destination’s location information.

III. OVERVIEW OF M-DART AND AOMDV ROUTING PROTOCOLS

A. M-DART Routing Protocol

M-DART protocol is based upon dynamic addressing paradigm. By means of dynamic addressing, DHT based algorithm is able to implement hierarchical routing in a feasible way, reducing so considerably the routing state information maintained by each node. Since the whole routing process is based on the transient network addresses, they have to be efficiently distributed across the network. The mapping between node identities and network addresses is provided by a Distributed Hash Table (DHT) [10]. The DHT based multi-path routing protocol proactively discovers all the available routes between a source and a destination. Key Features of M-DART are:

1) Address Space: - The network addresses are strings of l

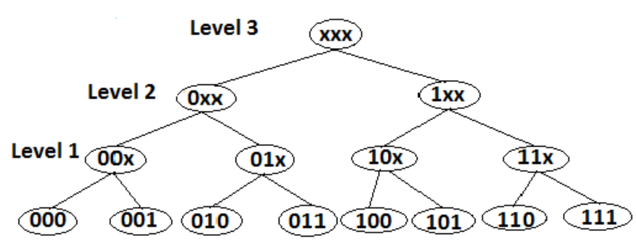

Figure 2: Address Space

bits, thus the address-space structure can be represented as a complete binary tree of l + 1 levels, that is a binary tree in which every vertex has zero or two children and all leaves are at the same level (Figure 2). In the tree structure each leaf is associated with a network address, and a inner vertex of level k, namely a level-k subtree, represents a set of leaves (that is a set of network addresses) sharing an address prefix of l – k bits. For example, with reference to Figure 2 the vertex with the label 01x is a level-1 subtree and represents the leaves 010 and 011. Let us define as level-k sibling of a leaf as the level-k subtree which shares the same parent with the level-k subtree the leaf belongs to. Therefore, each address has l siblings at all and each other address belongs to one and only one of these siblings. Referring to the previous example, the vertex with the label 1xx is the level-2 sibling of the address 000, and the address 100 belongs only to this sibling.

In Fig. 3, the address space is alternatively represented as an overlay network built upon the underlying physical topology.

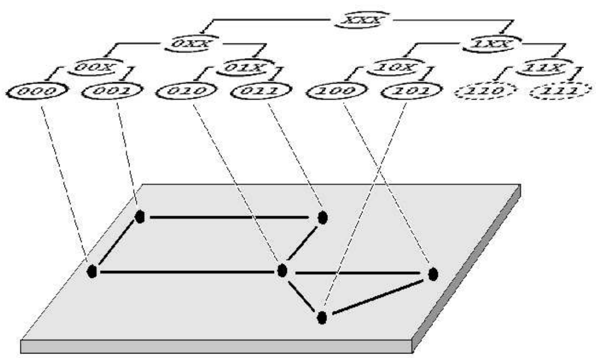

Figure 3: Relationship between address space and physical topology

Its tree-based structure offers simple and manageable procedures for address allocation, avoiding relying on inefficient mechanisms like flooding.

2) Route Discovery and Packet Forwarding: -Each node maintains a routing table composed by l sections, one for each sibling, and the k-th section stores the path toward a node belonging to the level k sibling. Each section stores five fields: the sibling to whom the entry refers to, the next hop, the cost

Table 1
Routing table for Node 001

Sibling id	Next hop	Route cost	Net_id	Route log
000	000	C(001,000)	MIN_ID(n) n in 001	000
01x	000	C(001,000)+ MIN_C(000,n) n in 01x	MIN_ID(n) n in 01x	010
	011	C(001,011)	MIN_ID(n) n in 01x	010
1xx	000	C(001,000)+ MIN_C(000,n) n in 1xx	MIN_ID(n) n in 1xx	100
	011	C(001,011)+ MIN_C(011,n) n in 1xx	MIN_ID(n) n in 1xx	100

needed to reach a node belonging to that sibling using the next hop as forwarder, the network id used for address validation and the route log used by the loop avoidance mechanism. Table 1 show the routing table of node 000 for the network depicted in Fig. 3. The table has three sections: the first stores all the routes toward the node 000, the second toward a node belonging to the sibling 01x and the last toward nodes belonging to the sibling 1xx. The routing state information maintained by each node is kept consistent through the network by means of periodic routing updates exchanged by neighbor nodes. Each routing update stores l entry and each entry is composed by four fields: the sibling id, the cost, the network id and the route log. The packet forwarding process exploits a hop-by hop routing based on the network addresses. To route a packet, a node compares its network address with the destination one, one bit at time starting with the most significant (left side) bit, say the l-th. If the i-th bit is different, the node forwards the packet towards one the route stored in the i-th section. With reference to the previous example, if the node 001 has to send a packet to the node with the address 101, then it will forward the packet to the next hop stored in the third section (i.e the node 011).

B. *AOMDV Routing Protocol*

AOMDV was developed mainly for highly dynamic ad hoc networks where link failures and route breakages occur very frequently. It discovers multiple routes to destination in active communication. AOMDV uses sequence numbers to determine the freshness of routing information to avoid routing loops. It is a timer-based protocol and provides a way for mobile nodes to react to link breaks and topology changes.

Table 2
Routing Table of AOMDV

Destination
Sequence Number
Advertised hop Count
Next hop {(next hop 1, hop count 1), (next hop 2, hop count 2),…..}
Expiration time out

AOMDV uses three types of control message: route error (RRER), route request (RREQ), and route reply (RREP) to discover routes, that are sent to port 654 using User Datagram Protocol (UDP). If a node needs a route to send data packets, it broadcasts RREQ throughout the network. When a node receives a RREQ packet, then it checks the destination address field of RREQ. If it has information about a destination or it is destination itself, it uses RREP packet to unicast to the source node. If it does not have a route to destination and its multiple alternative paths are not available, it sends RRER message back to the upstream node. AOMDV has 5 fields in the routing table as shown in Table 2.
AOMDV uses the advertised hop count field for multiple route entries. It uses next hop lists in the routing table, to define multiple next hops with relevant hop counts A node updates its advertised hop count for a destination whenever it sends a route advertisement for the destination [7].

IV. SIMULATION RESULT

We use network simulator ns2 to analyze M-DART and AOMDV routing protocols. We compare the results of M-DART routing protocol with AOMDV protocol by using the following parameters:

- Average Throughput:- Average rate of successful packet delivery. It will be measured in kilo bits per second (kbps).
- Packet Delivery Ratio (PDR):- The ratio of data packets delivered to the destination to those sent by the sender.
- Average End to end delay:- an end-to-end transmission delay of data packets that are delivered to the intended destination successfully.
- Average energy consumption:- average energy consumption per node.

We will analyze average throughput, PDR, and Average End to End delay by varying the number of nodes between 50 to 400. This is done to show the Scalability of M-DART for large number of nodes. Average energy consumption will be analyzed by varying the simulation time between 100 to 800 seconds. This is done to show the durability of the routing protocols. A 802.11 (IEEE wireless standard) network is used for the simulation of M-DART and AOMDV protocols. The mobility parameters have been set to simulate low mobility, because the transmission range requires lower speed values in order to allow the routing protocols to build reliable paths. More specifically, the speed is taken in the [0.5m/s; 1.5m/s] range.

A. *Average Throughput*

As shown in Figure 4, for small number of nodes (<100) , the throughput of M-DART is very slightly better than AOMDV. AOMDV behaves like M-DART up to 100 nodes, but it starts to behave poorly beyond this since it works on On-Demand technology.

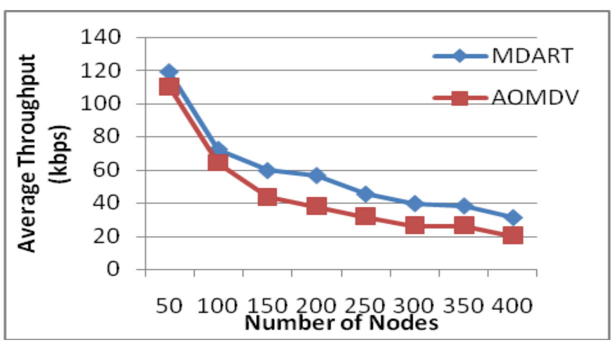

Figure 4: Average throughput over number of nodes.

As the number of nodes increases, the difference in throughput becomes large which shows the M-DART is Scalable due to its DHT technique. For large number of nodes (>300) the throughput of M-DART becomes about 1.8 times that of AOMDV.

B. *Packet Delivery Ratio (PDR)*

Many protocols in MANETs use packet delivery ratio (PDR) as a metric to select the best route, transmission rate or power. As shown in Figure 5, at 50 nodes, AOMDV has better PDR than M-DART.As the number of nodes increases, M-DART shows better PDR than AOMDV. Same as with throughput, for large number of nodes (>300) MDART has about 1.8 times PDR than that of AOMDV.

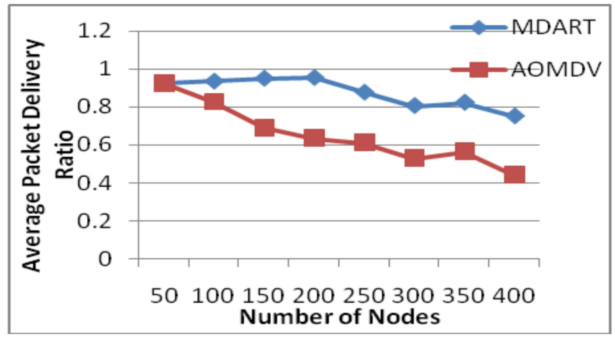

Figure 5: Packet Delivery Ratio over number of nodes.

C. *Average End to end delay*

As shown in Figure 6, for small number of nodes, AOMDV and M-DART shows approximately same End to End Delay. As the number of nodes increases, End to End Delay of M-DART grows linearly, whereas AOMDV shows exponential growth. For large number of nodes, End to End Delay of AOMDV is more than 5 times than that of M-DART. The delay of AOMDV increases dramatically because, the nodes queue packets while they select a different route when the primary route fails due to congestion. Reactive protocols must first determine the route, which may result in considerable delay if the information is not available in caches.

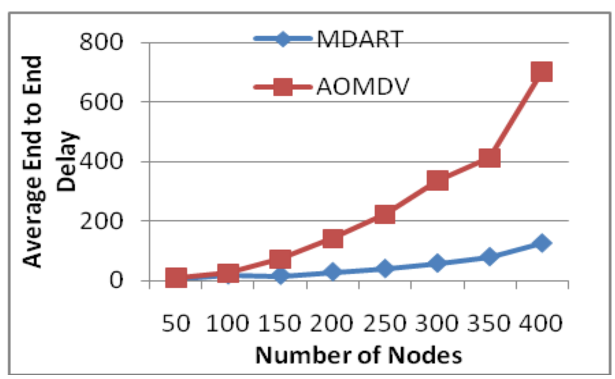

Figure 6: Average End to End Delay over number of nodes

D. *Average Energy Consumption*

Because of DHT paradigm in M-DART energy required is less as compared to protocols which are based on On-Demand paradigm. As shown in Figure 7 energy consumed in M-DART is less as compared to AOMDV especially when the simulation time is increased beyond 500 seconds.

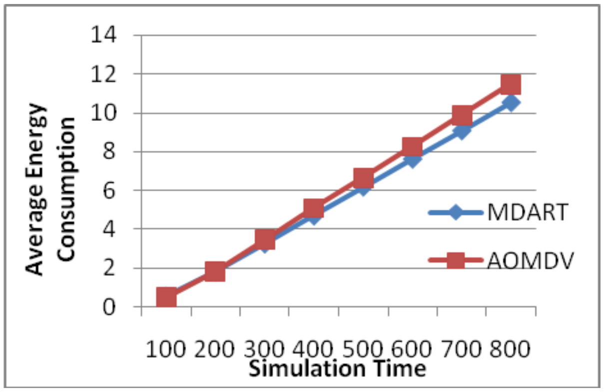

Figure 7: Average energy consumption over simulation time.

V. CONCLUSION

DHT based multipath routing supports scalability in various wireless networks. M-DART is an efficient protocol which gives improved performance in large networks. We have analyzed that the average energy consumption of M-DART is lower than AOMDV by 8.2%. We have also found that when number of nodes grows, the performance of other multipath routing protocols like AOMDV is not appropriate while M-DART is performing better in terms of Throughput (1.6 times), PDR (1.7 times), End to End Delay (5 times). Because of better routing paradigm in M-DART scalability is achieved as the number of entries in DHT are less i.e. log(n).

REFERENCES

1. S. Basagni, "Mobile ad hoc networking" 2004, Hoboken, NJ: John Wiley. xvi, 461.
2. C.E. Perkins, and T.J. Watson, "Highly dynamic destination sequenced distance vector routing (DSDV) for mobile computers," Proc. ACM Communications, Architectures, Protocols and Applications, vol. 24, pp. 234-244, 1994.
3. T. Clausen and P. Jacquet "Optimized Link State Routing Protocol (OLSR)." RFC 3626, IETF Network Working Group, October 2003.
4. M. Caleffi and L. Paura, "M-DART: Multi-path Dynamic Address RouTing" , Wirel. Commun. Mob. Comput. pp: 1–20, 2010.
5. C. E. Perkins, E. M. Royer, and S. Das, "Ad hoc On-Demand Distance Vector (AODV) Routing," RFC 3561, (2003) IETF.
6. D. Johnson, Y. Hu, and D. Maltz, "The Dynamic Source Routing Protocol (DSR) for Mobile Ad Hoc Networks for IPv4," RFC 4728, 2007.
7. M. Z. Oo , M. Othman , "Performance Comparisons of AOMDV and OLSR Routing Protocols for Mobile Ad Hoc Network", Second International Conference on Computer Engineering and Applications, 2010.
8. I. Chlamtac, M. Conti, J. Liu, Mobile ad hoc networking: imperatives and challenges. Ad Hoc Networks July 2003; 1(1):13–64.
9. J. Eriksson, M. Faloutsos, S. V. Krishnamurthy, "Scalable ad hoc routing: the case for dynamic addressing", IEEE, pp: 1108-1119, 2004.
10. A.C. Viana, M. D. de Amorim, S. Fdida, J.F. de Rezende, "Self organization in spontaneous networks: the approach of dht based routing protocols". Ad Hoc Networks, September 2005; 3(5):589–606.
11. J. Eriksson, M. Faloutsos and S. Krishnamurthy. "DART: Dynamic Address RouTing for Scalable Ad Hoc and Mesh Networks". in IEEE-ACM Transactions on Networking, vol. 15, no. 1, April 2007, pp. 119-132.
12. Caleffi, M., Ferraiuolo, G., and Paura, L., "Augmented Tree based Routing Protocol for Scalable Ad Hoc Networks", in MHWMN '07: Proceedings of the Third IEEE International Workshop on Heterogeneous Multi-Hop Wireless and Mobile Networks, 2007.
13. M. Caesar, M. Castro, E. B. Nightingale, G. O'Shea and A. Rowstron. "Virtual ring routing: network routing inspired by DHTs". In Proc. Of SIGCOMM, 2007.
14. C. Marcello, "Mobile Ad Hoc Networks: the DHT paradigm" ,IEEE, 2009.
15. Z. Bo, W. Yingyou, Z. Hong, "KDSR: An Efficient DHT-based Routing Protocol for Mobile Ad Hoc Networks", Ninth International Conference on Hybrid Intelligent Systems, 2009.
16. S. Du, A. Khan, C.S. Pal, A. Post, A.K. Saha, P. Druschel, D.B. Johnson, R. Riedi, ":Safari: A self-organizing, hierarchical architecture for scalable ad hoc networking". Ad Hoc Network 2008; pp. 485–507.

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