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EFFICIENT MULTICAST DATA REPLICATION APPROACH FOR POWER CONSUMPTION IN MANET

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ABSTRACT

Mobile Ad hoc Network (MANET) consists of mobile nodes. Nodes are connected without any infrastructure. MANET ensures that lack of infrastructure, self organization and no access point. Mobile nodes are sharing their data whenever and wherever it's needed. To maintain the effective data sharing, the data replication technique is needed. The main aim of the research work is to develop the data replication algorithm based on multicasting, data access method and power consumption in order to provide the minimum power consumption and high data availability rate in the network. Due to the presence of the network partition, mobile nodes in one partition are not able to access the data hosted by nodes in the other partition. So the performance of data access is degraded. Existing methods aims at balancing trade-off between energy consumption, data availability and delay. In proposed method we are focussing on balancing between data accessibility, power consumption and data availability ratio. In first phase, the multicast approach is proposed to achieve higher data availability. In second phase, the data replication procedure is proposed to ensure the higher data replication rate. In third phase, the data accessibility method ensures the more data accessibility rate. In fourth phase the power consumption procedure to ensure minimum transmission and reception power. By simulation results show that the proposed scheme achieves better performance than the existing methods like DAFN and OTOO.
Keywords: *MANET, Power Consumption, Data Accessibility, End To End Delay, Overhead, Network Lifetime, Network Partition And Data Replication Procedure.*

1. INTRODUCTION

A. *Mobile Ad Hoc Networks (MANET)*

A Mobile ad hoc network (MANET) is a wireless network consisting of mobile nodes, which can communicate with each other without any infrastructure (base-stations) support. The nodes are free to move randomly and organize themselves arbitrarily. Every node communicates via wireless radios that have limited transmission capabilities. These networks introduced a new art of network establishment and can be well suited for an environment where either the infrastructure is lost or where deploy an infrastructure is not very cost effective. However in this case, the nodes are limited to send and receive information but do not route anything across the network. It can turn the dream of getting connected "anywhere and at any time" into reality. Typical application examples include a disaster recovery or a military operation. Not bound to specific situations, these networks may equally show better performance in other places.

B. Data Availability and Need of Data Replication

Data availability means where the availability ensures that the data can be successfully transmitted from the source to the destination in a timely manner. It is assumed that the application layer does not use encryption and expects the underlying network services to be secure. Data Replication is technique which enhances data availability by making copies of data items. Furthermore there are various issues arise in MANET which leads to problem in data replication. Replication allows better data sharing. It is a key approach for achieving high availability. It is suitable to improve the response time of the access requests, to distribute the load of processing of these requests on several servers and to avoid the overload of the routes of communication to a unique server.

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C. Issues concerning Data Accessibility

Data accessibility means that the number of successfully serviced requests divided by the total number of data item requests generated by all mobile hosts in the network. Some of the following major issues concerning data accessibility is given below:

• *Frequent disconnection of mobile hosts*: Mobile hosts often get disconnected from the network due to various factors like power failure or their mobility. In addition, some mobile users switch their units on and off regularly to save power, causing more network disconnections. Servers which hold the data cannot provide services if they are disconnected from other mobile hosts. Thus, ideally, the replication algorithm should be able to determine when a particular mobile host would be disconnected and, accordingly, replicate its data items in a different server to improve data accessibility.

• *Network partitioning*: Due to frequent disconnection of mobile hosts, network partitioning occurs more often in MANET databases than in traditional databases. Network partitioning is a severe problem in MANET when the server that contains the required data is isolated in a separate partition, thus reducing data accessibility to a large extent. Therefore, the replication technique should be able to determine the time at which network partitioning might occur and replicate data items beforehand.

2. RELATED WORK

Rashid Azeem and Muhammad Ishfaq Ahmad Khan [1] offered a survey and classification of Data Replication techniques for MANETS Databases. They were evaluated the present replication techniques depend on how they addressed the recognize matters. They have recognized replication techniques for exacting applications. In this survey, they explained a numeral of open research troubles. They suggested that the replication techniques must be capable to approximate the workload of the server. In adding, network partitions might reconnect after some time, reasoning data replicated across the partitions to be unnecessary, the replication technique should be capable to eradicate replica doubling to progress data ease.

Rajeev Kumar and Prashant Kumar [2] proposed the replica allocation technique based on cluster for MANETs. Here each mobile node is associated with a cluster and each cluster has its cluster head (CH). Each CH will maintain an Available Replica Table (ART). Whenever a node requires a new data item then node has to send the request to the CH. Now CH will check the id of required data item in its ART, if found the data id, then the request is redirected to the node with node-id pertaining to that item-id in ART. When a node receives a data item then, it will make a replica of it for future use and an update message was sent to the CH.

Yang Zhang et.al [3] proposed the several data replication schemes to improve the data availability and reduce the query delay. The basic idea was to replicate the most frequently accessed data locally and only rely on neighbor's memory when the communication link to them was reliable. They proposed schemes to balance the trade-offs between data availability and query delay under different system settings and requirements.

Nishant Gupta et.al [4] proposed an efficient data replication technique for Mobile Ad-hoc networks that improve data availability by considering all the issues related with MANET such as power consumption, resource availability, response time and consistency management. This replication technique made data replication effective as it replicate data items on the basis of access frequency of data items, current network topology and stability of wireless links. It improved the response time and maintained consistency. However the performance of our Algorithm was yet to be measured in terms of the percentage of transactions successfully executed, energy consumption of servers and clients, and the average difference in energy consumption between two servers.

Kuppusamy et.al [5] proposed Adaptive Push and Pull Algorithm for Clusters (APPC) and Cluster Based Data Consistency (CBDC) approach to address the consistency requirements and maintenance in mobile ad hoc network. The Cluster heads (CH) shared their information with neighbors to improve the performance. Thus the cooperative caching improved the data availability in MANET. Also Adaptive Push and Pull Algorithms for Cluster proposed to improve the data consistency among the source and caching Mobile Nodes. The combination of push and pull algorithm for clusters improved the data consistency among source and cache copies by associate with Time to Live (TTL) values.

Zeina Torbey et.al [6] presented the CReaM, a user-Centric REplicAtion Model for mobile

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environment that gives priority to the users by letting them determine the amount of resources they assign to the system. In this paper, they focussed on CReaM's autonomic behavior that generates replication requests based on resource monitoring and user settings. Simulation-based evaluation of CReaM, which shown its efficiency comparing with a periodical model; indeed, CReaM gave the same rate of data availability.

Hoa Ha Duong et.al [7] proposed a stable group creation algorithm based on long lasting connectivity. While data sharing systems for MANET already exist, both the use of semantic information and of temporal stability were new in this domain. They illustrated the interest of the proposed algorithms by showing how a wiki service on MANETs would benefit from them. The proposed distributed data replication algorithm to be used for data sharing in Mobile Ad hoc Networks (MANETs). The system replicates data before users access them. To this purpose, it used a predictive algorithm based on semantic information about the user and the data and previous access patterns. It also aimed at creating enough replicas to prevent data loss in case a peer unexpectedly disappears or a partition occurs.

Arathi.R.R. et.al [8] introduced the Time Based Approach which provided the access to recent data on demand basis. In this system, the data came along with a time stamp. This approach provided the data availability even with limited resources. They considered all these issues and proposed a new cache protocol based on time specification. Hence any information that was accessed can be made to be relayed along with time related information. If this information was already present then it checks if the received one was cached information and if it is latest, makes an update. Moreover since all cached information were time specific, the information can be automatically deleted from the cache after the speculated time interval. This time variant may either be proposed by the data server or by the intermediate node that is responding to the particular information access request.

Takahiro Hara [9] quantified the impact of node mobility on data availability in MANET. In mobile ad hoc networks, there are many applications in which mobile users share information, e.g., collaborative rescue operations at a disaster site and exchange of word-of-mouth information in a shopping mall. For such applications, improving data availability is a significant issue and various studies have been conducted with this aim. However, each of these conventional works assumed a particular mobility model and did not fully investigate the influence of the mobility. He considered several factors that affect the data availability.

Pooja Sharma et.al [11] developed Cluster based data replication technique for MANET. In this research work, performance analysis of existing Cluster-based MANETs techniques based upon of available techniques into various classes, with respect to various issues such as Client/server classification, Data availability and data consistency, Partition detection, etc. is carried out.

Prashant Srinivas et.al [14] proposed an approach to reduce the data traffic and to increase an data available in the network. Here, each mobile node has a buffer for temporary storing data segment for a particular time, If a mobile node requests for a particular data segment and the request is multi hoped, then first request is sent to its (requester) neighbor node, neighbor node first match requested data segment with holed copy of data segment, if it is matched the request will be responded by this neighbor otherwise request will be routed to mobile server. In this way the overhead of the server and data traffic in the server zone will be reduced. The proposed method reduces time consumed by multiple nodes and data availability will be enhanced.

Hauspie et al. [15] developed a new metric for evaluating link robustness that is used to detect network partitions without using the services of a GPS. According to this technique, the decision to replicate data items is taken not only at the time of detecting a network partition, but also during the time when the condition of the wireless connections worsen in terms of reliability, bandwidth and delay. This is because in high density networks, the connection is reliable only as long as the server is near the client as they would be separated by fewer hops. In such a case, replicating a data service on a host that is closer to the client enhances the chances of the client being able to access the data on the server.

Chen and Nahrstedt [16] proposed a distributed data lookup algorithm to address the issue of identification of data availability in MANET and a predictive data replication algorithm. This technique uses the group-based data accessibility

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scheme. In such a scheme, a set of mobile nodes forms a separate group and the nodes within this group collectively host a set of data items that are available for data access to all the other nodes of the group, while reducing data redundancy within that group.

Moon et al. [18] introduced an energy efficient eager replication scheme, named E-DRM (eager replication extended database state machine), that have energy restrictions and achieve data consistency across the network reducing the number of broadcast messages.

The paper is organized as follows. The Section 1 describes introduction about MANET, issues concerning data accessibility and need for data availability. Section 2 deals with the previous work which is related to data replication. Section 3 is devoted for the implementation of DRA based on data replica configuration. Section 4 describes the performance analysis and the last section concludes the work.

3. IMPLEMENTATION OF PROPOSED ALGORITHM

In the proposed algorithm, we used 4 modules to increase the data availability ratio and minimize the power consumption. In first module we use the concept of multicasting approach to increase the data availability rate. Here we use the reliable energy efficient multicasting routing protocol to improve energy efficiency in MANET. In second module, we use our data replication procedure [22]. In third module, the data accessibility method is chosen to enhance the source, destination nodes data access level. In fourth module the power consumption procedure is proposed to ensure minimum power transmission at source and destination. The description of the following modules is follows:

A. Multicast Routing Protocol

Multicasting is another important routing operation to transmit the message from one mobile host to a number of mobile hosts. Many applications require disseminating information to a group of mobile hosts in a MANET. These applications include distributed games, replicated file systems, teleconferencing, etc. A single-source multicasting in MANET is defined by delivering multicast packets from a single-source node to all member nodes in a multi-hop communication manner. A multi-source multicast is the one that each member can be the source of message sender of the other members. Although multicasting can be achieved by the multiple point-to-point routes, constructing a multicast topology for delivering the multicast packets always provides a better performance.

In our proposed approach, we use reliable energy efficient multicast protocol [32] to improve the energy efficiency. This protocol selecting neighbors in the multicast tree is based not only on the link distance, but also on the error rates associated with the link.

Let $p_{k,l}$ denote the packet error probability of link (k , l). The expected number of transmissions to reliably transmit a single packet across this link is $1 / (1 - p_{k,l})$. The expected energy requirements to reliably transmit a packet across the link (k , l). is given by $E_{k,l}$ (reliable)= $E_{k,l} /(1- p_{k,l})$. The computation of a minimum-cost multicast tree will follow three steps as described below:

Step 1: Similar to Prim's algorithm, the reliable algorithm greedily adds links to an existing tree such that the incremental cost is minimized. However, because reliable protocol works on reliable transmission costs, these costs are a function of both the link distance and link error rates. The RBIP algorithm iteratively adds the minimum cost link from the set of eligible links to an existing tree. Hereafter, an energy-efficient broadcast tree has been formed.

Step 2: Reliable protocol prunes those nodes from the tree that do not lead to any multicast group member. This processing is performed in a single post-order traversal.

Step 3: Finally, the sweep operations are performed on the remaining tree in post-order. A node r is transferred from being a child of its parent s to being a child of its grandparent t if doing so reduces overall energy requirements for reliable packet transmission costs.

B. Data Replication Procedure

The main proposal of our Data Replication Algorithm is to construct a data replication configuration that will present to each mobile node m_i, an energy efficient plan on how to replicate its local di structures. A data replication configuration is an energy efficient (interpret, mark)-combination that dictates how many translating and marking operations are necessary per distance, such that this distance can be preserved in cases of mobile node failures. It is very important to notice that if energy conservation was not important then we could have opted for a scheme that replicates each distance d_i to the entire network.

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The following steps to demonstrate the replica of the data items:

Input: A mobile node $m_i \in m_p$, a threshold parameter q_{min} representing the minimum number of votes a mobile node must register.
Output: The data replication configuration (I,M) of m_i
procedure DRA($m_i \in m_p$)
Step 1: Find neighbor nodes of $m_i \in m_c$
MNH(si) Find hop-1 neighbors of m_i that belong to m_c
if (|MNH(m_i)| < q_{min}) then
MNH(m_i) recursively expand neighbors
end if
Step 2: Define possible interpret and mark (i,m)-combinations IM={(i, m): q_m>v/2, q_r_1, i+m>v}, where q = |MNH(mi)|
Step 3: Eliminate redundant (i,m)-combinations IM′={(i,m): (i,m)2IM, i+m=q+1}
Step 4: Rank the (i,m) in IM' according to f
(ix,mx) maxi≤|IM′ |f(I_i,M_i)
Step 5: Replicate the information to neighbors
q_i = select(MNH(mi),mx) // select a set of max neighbors
notify m□q_i (m, di) // replicate di to these maximum neighbors end procedure

C. Data Accessibility Method

In the Data accessibility method, each mobile host believes the sum of the access frequencies from itself and its nearby hosts. Here, the mobile node may reject data items frequently accessed by itself and replicate those frequently accessed by its nearby hosts. Here, mobile hosts consume more power when they access data items held by other hosts than when they access their own data items because the source, destination, and relaying mobile hosts need to send and receive data items.

In order to overcome this issue, each mobile host separately considers data accesses from itself and those from others. So, each mobile host determines the number of data accesses performed by itself and its nearby hosts to each of its own data items. If the host multiplies a weight to each of the two calculated numbers for each data item and sums them up. This value is used as a criterion for replica relocation in the proposed method. The following is the behavior of the when M_k accesses D_{fresh}, which is not held by itself.

The Mobile host M_k immediately replicates D_{fresh} and finishes the procedure if it has free memory space to create the replica. Otherwise, M_k floods mobile hosts within $h(\geq 4)$ hops with a data information request packet. This request packet includes M_i's host identifier and the list of data identifiers of data items held by M_k and D_{fresh}. If a mobile host, M_k, receives the query packet, it transmits a data information reply packet to M_k. This reply packet includes the host identifiers of M_k and M_j, access frequencies from M_k to data items included in the request packet.

$$\Delta_{j,k\to fresh} = \delta\left(b_{j,fresh} - b_{j,k}\right) + \gamma\left(\frac{U'_{j,fresh}}{F_{j,fresh}+1} - \frac{U_{j,k}}{C_{j,k}}\right) + W_{j,d}(y_i, d)$$
(1)

Where replication profit is derived as

$$W_{j,d}(y_{i,}d) = \begin{cases} \frac{sd}{n}\sum_{j\in N}(1-D_{j,d})\Delta F_{i,j}^{d}(y_i,d) & y_{i,d} < m \\ 0 & y_{i,d} = m \end{cases}$$
(2)

Replication profit is defined as replicating an additional packet of data item d to node i's buffer, which is determined by the popularity and availability of the data item, and the contribution gain that the node can provide to other nodes.

where the replication profit turns to zero if node i has already replicated s packets of data d. The derivation of sd and $F_{j,d}$ are indicate that the replication benefit provided by replicating a new packet of data d on node i should be the contribution gain that i can provide to other nodes if they currently cannot successfully retrieve d from the network. Here the contribution gain is determined from the popularity of data items.

The popularity of data items is obtained where each node maintains a data popularity table which records the average query rate to each data item from its local view. Each node counts the number of pending requests it has received and calculates the average query rate to each data item d as sd = n_d=n_{total}, where n_d is the number of requests for data item d, and n_{total} is the total number of requests. The popularity of data items can be derived as,

$$F_{i,d} = \sum_{b=s-y_{i,d}}^{\infty} f_{G_i^d(y)}(b) \tag{3}$$

Here $b_{j,k}$ indicates the access frequency from M_j to D_k. $U_{j,k}$ denotes the sum of access frequencies to D_k from mobile hosts within the h hops from M_j excluding those holding D_k.

δ, γ are predefined weights that give priorities to the first term i.e.access frequencies from M_j and the second term i.e.those from other hosts. Exclusively, the first and second terms denote the changes in the number of successful data accesses fromM_j andM_j's nearby hosts, respectively, when replacing D_k with D_{fresh}. The denominator of the second term becomes "$F_{i,fresh}$+1" due to the same reason.

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M_j selects D_k among its own data items so that $\Delta_{j,k\rightarrow fresh}$ has the positive maximum value and replaces D_k with D_{fresh}.

The proposed method improves data availability and balances the power consumption among mobile hosts while considering the replication profit. In particular, a mobile host can reduce its power consumption by replicating data items that are frequently accessed by itself but are not frequently accessed by its nearby hosts. Proposed schem can adjust data availability and power consumption by changing parameters δ, γ. If δ is set to a larger value than γ, each mobile host preferentially replicates data items frequently accessed by itself, and thus, its power consumption decreases. On the other hand, if δ is set to a smaller value than γ, each mobile host preferentially replicates data items frequently accessed by its nearby hosts and its power consumption increases. However, data availability becomes higher because those mobile hosts can share many kinds of data items and get more benefit from replication profit.

D. The Approach for minimum Power Consumption

Step 1: Transmit power is recorded in the data packet by every node lying along the route from source to destination and it is forwarded to the next node. The transmitted power is derived as,

$$P_{tx} = Transpower \frac{Sizeof\ ReqToSend + Sizeoforiginaldata + PRT}{Bandwidth} + Recpower * \left(\frac{SizeofCleartosend + Acksize + RERR}{Bandwidth}\right) \quad (4)$$

Step 2: When the next node receives that data packet at power P_{recv}, it reads the transmit power P_{tx} from the packet, and recalculates the minimum required transmit power P_{min}, for the precursor node.

$$Transpower\left(\frac{SizeofClearToSend + ACKsize + RERR}{Bandwidth}\right) + Recpower * \left(\frac{Sizeof\ Reqtosend + Datasize + PDR}{Bandwidth}\right) \quad (5)$$

$$P_{min} = (P_{tx} - P_{recv}) + P_{mar} + P_{wast} \quad (6)$$

To overcome the problem of unstable links due to channel fluctuations, a margin P_{margin} is included. Because the transmit power is monitored packet by packet, in our work, we maintain a margin of 10dB.

Step 3: The recalculated minimum required transmission power, P_{min} is sent to the precursor node through acknowledgement (ACK) packet. This packet contains the source, destination id, transmission and reception power.

Step 4: This ACK packet is received by the precursor node, it records the modified transmit power in the power table and transmits the remaining packets with P_{min}.

Step 5: When a node cannot find a record in the power table for a particular node, which will be the case when two nodes never exchanged packet before, it transmits with default power level 300 db.

4. PERFORMANCE EVALUATION

We use NS2 to simulate our proposed algorithm. In our simulation, 200 mobile nodes move in a 1200 meter x 1200 meter square region for 60 seconds simulation time. All nodes have the same transmission range of 250 meters. The simulated traffic is Constant Bit Rate (CBR). Our simulation settings and parameters are summarized in table 1.

Table1. Simulation And Setting Parameters Of DRA

No. of Nodes	200
Area Size	1200 X 1200
Mac	802.11
Radio Range	250m
Simulation Time	60 sec
Traffic Source	CBR
Packet Size	512 bytes
Mobility Model	Random Way Point
Antenna	Omni Directional
Routing Protocol	DSR

A. Performance Metrics

We evaluate mainly the performance according to the following metrics.

Control overhead: The control overhead is defined as the total number of routing control packets normalized by the total number of received data packets.

End-to-end delay: The end-to-end-delay is averaged over all surviving data packets from the sources to the destinations.

Data Availability Ratio: It is defined as the making the copies of data items which shared by several users in a particular point of time.

The simulation results are presented in the next part. We compare our proposed algorithm EMDRA with One to One Optimization Scheme (OTOO) [30] and Dynamic Access Frequency and

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Neighborhood DAFN [30] in presence of node mobility and energy consumption environment.

Figure 3 shows the results of average end-to-end delay for varying the nodes from 20 to 100. From the results, we can see that scheme has slightly lower delay than the OTOO [30] and DAFN [30].

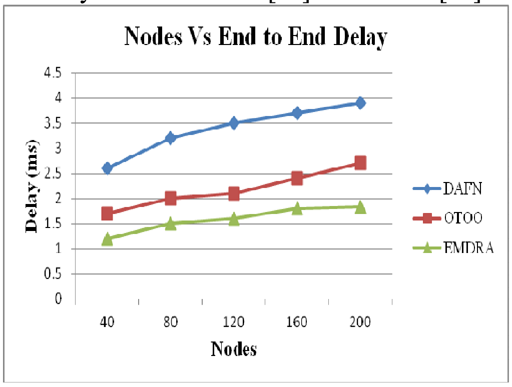

Fig. 3. Nodes Vs End To End Delay

Fig. 4, presents the energy consumption. The comparison of energy consumption for EMDRA, DAFN, OTOO It is clearly seen that energy consumed by EMDRA is less compared to OTOO and DAFN.

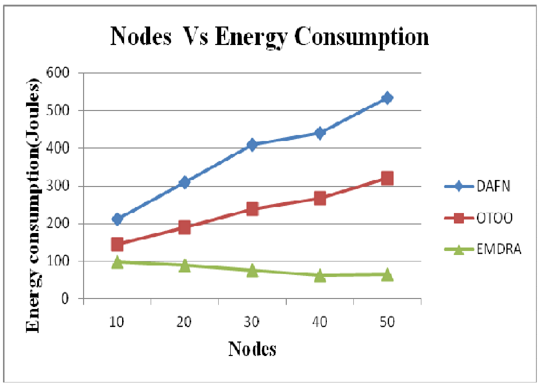

Fig. 4. No.Of Nodes Vs Energy Consumption

Fig. 5, presents the comparison of overhead. It is clearly shown that the overhead of EMDRA has low overhead than the OTOOand DAFN.

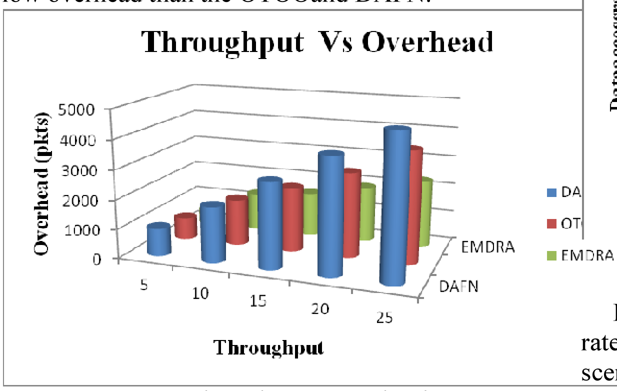

Fig. 5. Throughput Vs Overhead

Figure 6 shows the results of Mobility Vs Delay. From the results, we can see that EMDRA scheme has slightly lower delay than the OTOO and DAFN.

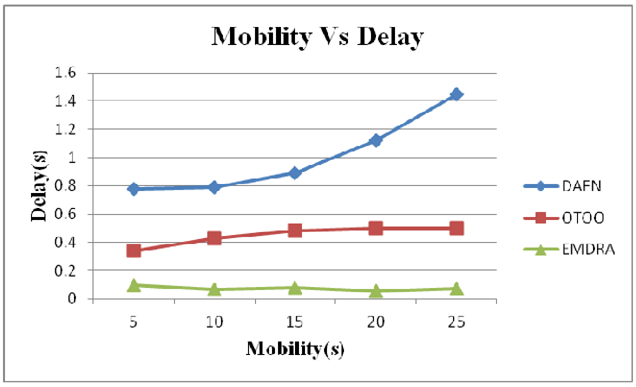

Fig. 6. Mobility Vs End To End Delay

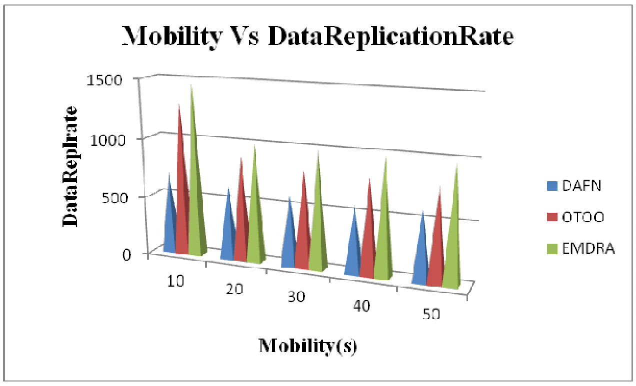

Fig.7 . Mobility Vs Data Replication Rate

Fig. 7 presents the comparison of data replication rate while varying mobility from 10 to 50. It is clearly shown that the data replication rate of EMDRA is higher than the OTOO and DAFN.

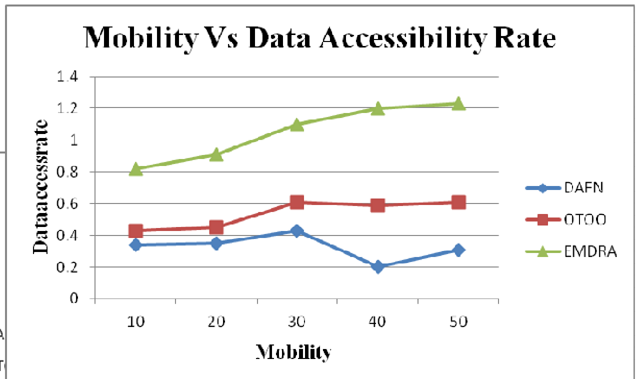

Fig.8. Mobility Vs Data Accessibility Rate

Figure 8 shows the results of data accessibility rate for the mobility 10, 20…50 for the 200 nodes scenario. Clearly our scheme EMDRA achieves data accessibility rate than the OTOO and DAFN.

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5. CONCLUSION

In MANET, mobile nodes connected without any access point. The replication technique makes data replication effective as it replicate data items on the basis of access frequency of data items, current network topology and stability of wireless links. It improves response time and maintained consistency. In this paper, we have developed an Efficient Multicast Data Replication approach for power consumption which attains minimum power consumption and provide high data availability rate to the multiple mobile nodes whenever required. Our scheme comprises the multicast protocol, data replica configuration, data accessibility method and power consumption procedure which has been made balance between the data accessibility, power consumption and data availability. By simulation results we have shown that the EMDRA achieves high data replication rate, data accessibility rate while attaining low delay, overhead, minimum power consumption than our proposed schemes DAFN and OTOO varying the number of nodes, node mobility and throughput.

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