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MEMAC: A New Algorithm for Relay Node Selection with Mobile Sink in MANET

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Abstract: The topology of the Mobile Ad hoc Networks (MANET) is altered frequently due to the nodes mobility. It also affects the path of transferring data from the member nodes to the sink. In this study, the sink is considered as mobile to collect the information from the member nodes. Initially the sink node is assigned with a current speed and direction. At each fixed intervals of time, the speed and direction of the sink is updated. The Mobility supported Energy aware Medium Access Control (MEMAC) protocol is implemented with IEEE 802.11 MAC to identify the direction and speed of the sink. The relay node is one of member nodes and is chosen based on the movement of sink node. The parameters like direction of mobility of sink, distance between sink to member, RSSI and residual energy of member node are utilized to find the relay node in the domain. The extensive simulation implemented with NS2 event driven simulator to validate the performance of the MEMAC algorithm. The experimental results shows that the MEMAC outperforms well compared to the previously stated algorithms in terms of relay node selection, path stability, data collection and throughput.

Key words: Mobility model, relay node, mobile sink, MANETs, throughput

INTRODUCTION

MANET consists of self configured nodes that are hosted over the service domain area. It makes collaboration among the participated node to forward the collected data to one another until it reaches the destination. It is multi hop network in which mobile node work together to form routes among the nodes to forward the data to the sink node (Zhang *et al*., 2014). As mobility in nature, the topology of the nodes in the MANET is changing rapidly. It leads several issues like routing, data collection, relay node selection, energy conservation, link reliability and also integrity of data. Mostly nodes in MANET are only limited power once deployed it is hard to replace or charge the power source is difficult or even impossible. So there is need of energy constrains while developing new communication scheme or protocols in MANET (Palaniappan and Chellan, 2015).

Most of the energy of the nodes is wasted due to routing and also idle listening these two is contradicting each other (Sivanesan and Thangavel, 2013, 2015). The more concentrate is in route selection the more listening is needed the data travel in the nodes vicinity which leads to energy loss (Nedumaran and Jeyalakshmi, 2015). The mobility of nodes breaks the link between the nodes of current transmission path is also affects the performance of the networks (Gursharan *et al*., 2014). In this scenario the member nodes are static, sink only is moving across the member nodes. Whichever node close to the sink in terms of direction and distance is act as a rely node to send the active probe message to the moving sink node for association. Upon association this node act as intermediate router between the sink and rest of the nodes in the network and all the collected and buffered data are forwarded only via this member node within the time span (Sharma *et al*., 2013; Sivanesan and Thangavel, 2013, 2015).

The sink node is going far away from the present relay node by check the distance and also beacon message, other nodes which are closer to the moving sink are trying to make the association to the sink node. The relay node selection is the important criteria that affect the path finding, energy consumption and also overall performance of the MANET. So this study, proposes new communication relay node selection mechanism to overcome the aforementioned issues.

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Literature review: Xia *et al*. (2013) proposed a novel on demand Trust based unicast routing protocol (TSR) for MANETs. TSR provides an adaptive prediction model to assess the reliability of the nodes in the network which is based on the past historical behavior of the nodes concern. The future behavior models of the nodes are predicted by using the fuzzy logic. The proposed TSR also incorporated with source routing mechanism. It is also implies a reasonable approach to found the shortest path between the sender to receiver that satisfies the security prerequisite by the application requirement, for data transmission. The performance of the proposed TSR outperforms well in terms of the metrics like packet delivery ratio and average end to end delay.

Sargolzaey *et al*. (2012) dealt with the problems of host mobility in MANETs. The impact of the host mobility causes the link failure between the nodes in the network. The link failure then breaks the paths among the networks. The numbers of route reconstructions are increased when the link failure increases. It also increases the utilization of energy, delay and minimizes the throughput. The most common reliable metrics like expiration period of links, probability of link reliable period, packet error rate between the links and received signal strength are considered to reduce the reconstruction of routes in the network. A new cross layer metric is calculates a unit weight function that mingle the abovementioned metrics based on their efficiency. The results of the proposed protocol reduce the route retransmissions effectively compared to others.

Kalwar and Sharma (2013) proposed an algorithm to find stable path for data transmission between sources to destination based on energy level of the nodes in the network. If the less energy nodes are present in the selected path, it will degrade the network performance. In this scheme, an energy conscious routing scheme is designed to select the MAX energy holding nodes. It calculates the maximum average energy paths for further data transmission. It always utilizes the path which is having the maximum energy nodes; it implies a reliable connection in the network. In order to ensure the performance of the network metrics, the paths for information transmission are chosen in such a way that the cumulative energy utilized among the paths to be minimized and exclusion of the minimal energy holding nodes. The extensive simulation was performed between the energy based routing and the proposed scheme which results the proposed one yields better performance and reduced energy utilization.

Kafhali and Haqiq (2013) discussed and analyzed the energy utilization issues on the existing ad hoc routing protocols in MANETs with various mobility models. The mobility models like random waypoint, Manhattan grid and reference point group are considered for analysis. Various traffic models like CBR, exponential and Pareto are also incorporated with patterns of mobility. The proposed scheme expresses the performance comparison of different routing protocols AODV, DSR and DSDV. The energy utilization due to different control packet types like MAC and routing during the transmission and reception are measured. Sharma *et al*. (2013) developed MR-MAC (Modified Relay-Medium Access Control) protocol. In which, more than one relays are utilized to convey the information from the sources to the sink. The role of one relay node is like a helper and the other one proceed as a standby node. This MR-MAC does not giving importance to the reliability of relay nodes alone. Always the relay nodes are considered to send data with high rate, due to interference it may lack to convey the data. Three parameters are utilized for computing the MR-MAC like data rate between the source to destination among the relay nodes, reliability of relay nodes and the energy utilized in the relay node.

Kulkarni and Yuvaraju (2015) analyzed the crucial issue like best effort route for communication of data packets and hence they presented the stable and reliable path for interrupt free communication on MANETs. The proposed protocol fixes the monitoring agents for collecting and calculating the metrics which are used to analyze the link stability. The fuzzy inference system was developed to estimate the route selection probability which is based on the metrics like, expiration of every link, probabilistic link reliable period, packet error rate and received signal strength for each link and residual energy of nodes. This protocol maintains the effective energy utilization in the network and ensures the optimum packet delivery ratio.

Proposed work: Figure 1 illustrates the propagation mechanism of proposed scenario. Here, the sink considered as mobile and the members are static nodes which are used to collect the information from area of interest. When the mobile node moves randomly among the network and connected to the members by sending the beacon message periodically this control message may consist of node id, Time stamp, ATIM, probe message for synchronization with members. The relay node is selected among the members in the domain. The information from the nearby nodes are buffered and forwarded to the sink passing through relay node only.

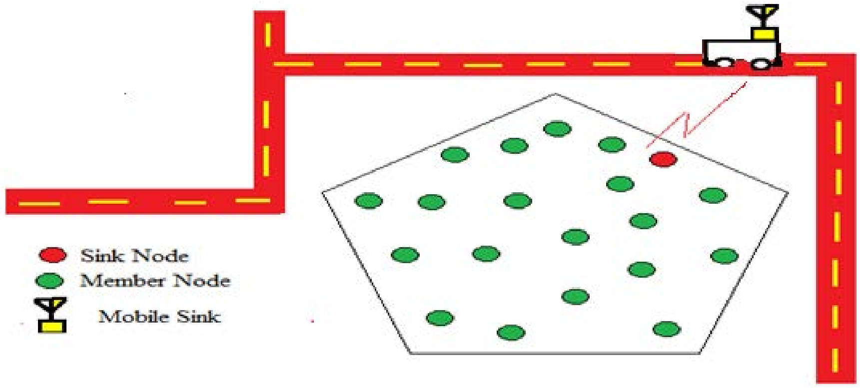

Fig. 1: Mobile sink architecture in MANET

MATERIALS AND METHODS

Proposed mobility model: In this proposed scenario, the sink is incorporated with different types of randomness of mobility. At initial level, the sink node is set with constant speed and direction. After each predetermined time span 't' the speed and direction of the mobile sink is being changed. The tth step of speed and direction is depends only the (t1)th step. It is computed by using Eq. 1 and 2.

$$V_t=\mu V_{t1}+(1\mu)\tilde{N}+\sqrt{(1\mu)}V_{t1} \quad (1)$$

$$L_t=\mu L_{t1}+(1\mu)L+\sqrt{(1\mu^2)}L_{t1} \quad (2)$$

Where:

- μ = The scaling factor which is in the range of, $0<\mu<1$ are the initial values of speed and direction of mobile sink
- V_t and L_t = The current speed and direction of the mobile sink at time span t
- V and L = The mean values of speed and direction of sink
- V_{t1} and L_{t1} = The random variables

The next position of the sink is calculated by the new speed and direction of sink. The new location of the mobile sink (X_t and Y_t) is computed by the following Eq. 3 and 4:

$$X_t=X_{t-1}+V_{t-1}\cos(L_{t-1}) \quad (3)$$

$$Y_t=Y_{t-1}+V_{t-1}\sin(L_{t-1}) \quad (4)$$

Relay node selection: After the prediction of mobility pattern of mobile sink, the relay node will be selected closer to the boundary of the sink. The parameter received signal strength RSSI is used to calculate the distance between the sink to the member nodes. If the obtained value of RSSI is low then the distance between the sink to the respective member is high and vice versa. The RSSI will be computed using Friis transmission formula. If any member found with less distance to the sink and having maximum residual energy will select as a relay node in the path of data transmission. The responsibility of the relay node is to gather the information from the nearer nodes vicinity and convey the same to mobile sink.

Calculation of energy metrics and distance: Let the $E_{remaining}$ will be the remaining energy of the nodes in the network, will be the initial energy of the node and $E_{utilization}$ will be the energy utilized by the respective nodes. The residual energy of the nodes can be calculated using Eq .5:

$$E_{remaining}=E_{initial}-E_{utilization} \quad (5)$$

the energy utilization of the nodes can be described by Eq. 6:

$$E_{utilization}=E_{transmission}-E_{reception} \quad (6)$$

the distance between the sink to member node is calculated by RSSI and it is calculated by using Eq. 7:

$$P_r(D)=\frac{P_t G_t G_r h_t^2 h_r^2}{D^4 P_l} \quad (7)$$

Where:

- P_r = The received power for the given distance D
- P_t = The signal power transmitted
- G_t = The gain of transmitter
- G_r = The gain of receiver
- P_t = The path loss
- h_t = The height of transmitting antenna and the height of receiving antenna is h_r

The value of remaining energy of the respective node is compared to the predefined threshold (i.e., not <50% of the initial energy) and using the friis transmission formula the distance between the sink to respective member is also calculated.

Alogrithm 1:

If $E_{remaining}$ is maximum and Distance 'D' is minimum then
    The member node is selected as relay node
Else
    The member node is not selected as relay node
End if.

Based on the algorithm the relay node is selected for further data forwarding to the mobile sink.

RESULTS AND DISCUSSION

The proposed MEMAC is compared and evaluated with MR-MAC protocol and IEEE802.11 MAC. The performance indicators like throughput, energy utilized by the nodes, delay and drop of packets are evaluated and compared with the MR-MAC and IEEE802.11 MAC. The parameters and the associated values are tabulated in Table 1. The MEMAC simulated with the NS2 open source environment, the numeric results are illustrated in Table 2 and discussed in this study.

Figure 2 and 3 reveals that the pockets load in Kbs versus energy consumption and delay. From Fig. 2, it shows that the average energy utilization of the MEMAC gradually increases when the load increases. However, the energy consumption is reduced due to the dynamic relay node selection in the proposed algorithm. From Fig. 3, it shows that the delay of the MEMAC scheme is getting minimized when compared to the others. The delay is minimal when the load of the network is minimal. In Fig. 3, the delay difference between the MEMAC and MR-MAC is very minimal deviation in high load conditions.

Figure 4 is plotted between packet loads in Kbs versus number of packets dropped. It shows that the proposed system reduces the packets drop in a considerable amount, since proposed system uses the new relay node mobility mechanism.

Figure 5 and 6 are plotted between loads in different data rates versus number of packet dropped, throughput, respectively. It shows that the proposed MEMAC protocol reduces the packets drop compared to the existing stated technique due to appropriate relay selection nearer to the mobile sink. In Fig. 6 the throughput of MEMAC is getting improved minimal compare to the existing stated techniques. The overall numeric simulation results described in Table 2 shows that the proposed technique enhances the parameters like energy utilization, delay, drop and throughput.

Table 1: Simulation settings

Parameters	Values
Number of nodes	20, 40, 60, 80 and 100
Area	1250×1250 m
MAC protocol	MEMAC PCF
Radio range	250 m
Simulation time	90 sec
Routing protocol	DSR
Packet size	512 B
Speed	10 m sec^{-1}
Pause time	5 sec
Rate	250-500 Kb sec^{-1}
Mobility model	Random walk
Tx power	0.660 W
Rx power	0.395 W
Initial energy	14.1 J

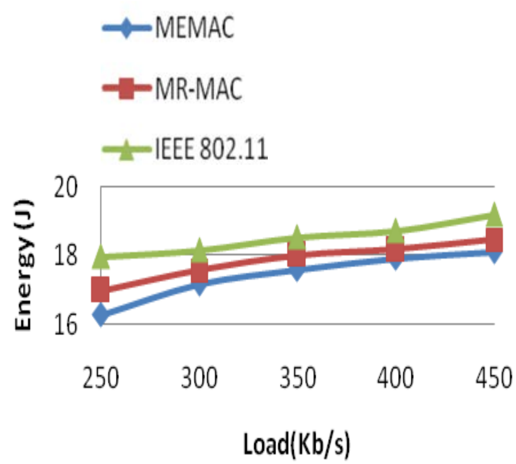

Fig. 2: Load vs. energy utilization

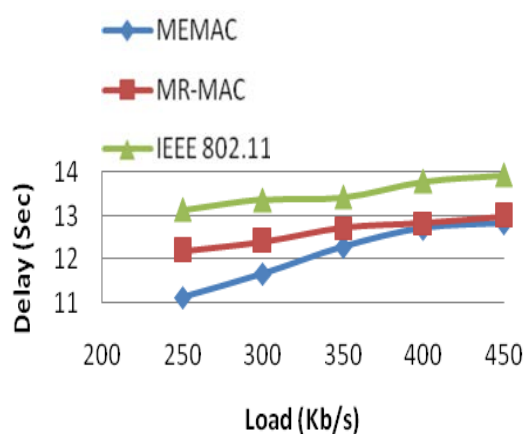

Fig. 3: Load vs. delay

Table 2: Numerical results

	Energy			Delivery ratio			Delay			Drop			Throughput		
Load (Kbs)	ME MAC	MR-MAC	IEEE 802.11	ME MAC	MR-MAC	IEEE 802.11	ME MAC	MR-MAC	IEEE 802.11	ME MAC	MR-MAC	IEEE 802.11	ME MAC	MR-MAC	IEEE 802.11
250	16.2618	16.9681	17.9687	0.01795	0.00795	0.0019	11.13825	12.1982	13.1340	38110	38720	39320	0.1358	0.13	0.1128
300	17.1727	17.5798	18.1567	0.02617	0.0177	0.0121	11.67374	12.4042	13.3598	44613	45345	46327	0.1604	0.156	0.1404
350	17.5896	18.0096	18.5389	0.03271	0.02591	0.0219	12.2904	12.7150	13.4120	52566	53998	55569	0.182	0.1791	0.159
400	17.9220	18.1720	18.7290	0.04073	0.0359	0.0307	12.71188	12.8218	13.7868	57958	58762	59780	0.2015	0.195	0.185
450	18.1137	18.4645	19.1860	0.04575	0.03786	0.0349	12.8295	12.9912	13.9297	64332	65992	66898	0.2241	0.2149	0.2014

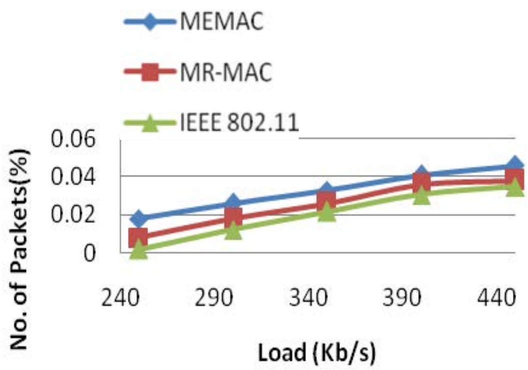

Fig. 4: Load vs. delievery

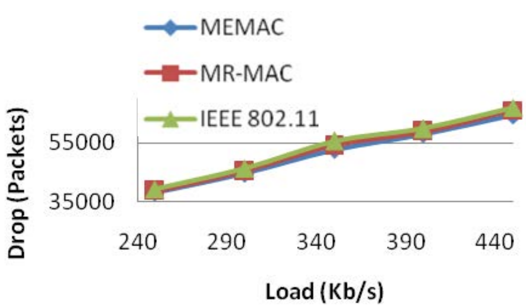

Fig. 5: Load vs. drop

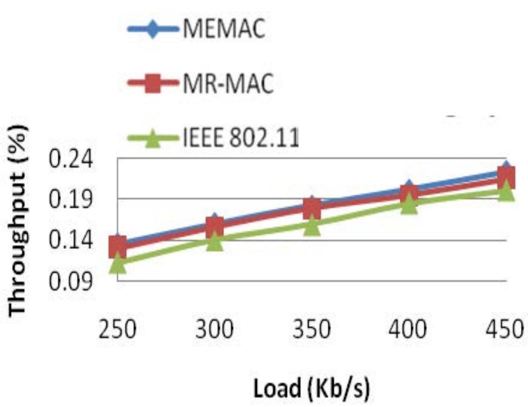

Fig. 6: Load vs. throughput

CONCLUSION

In this study, sink node is act as a mobile node to collect the information from the member nodes. Initially, the sink node is assigned with a predefined speed and direction. At each fixed intervals of time, the speed and direction of the sink is updated. The relay node is one of member nodes and is chosen based on the mapping of the sink node. The parameters like direction of mobility of sink, distance between sink to member, RSSI and residual energy of member node are utilized to find the relay node in the domain. The experimental results shows that the MEMAC outperforms well compared to existing stated algorithms in terms of relay node selection, path stability, data collection and throughput parameters.

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