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Mobility Aware Clustering Routing Algorithm (MACRON) to improve lifetime of Wireless Sensor Network

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***Abstract**: In wireless sensor network energy consumption is the recent research trend. Sleep scheduling and clustering of nodes in mobile environment are two different approaches adopted to elongate the life of network. In this paper Mobility Aware Clustering routing algorithm (MACRON) is proposed by integrating two challenging approaches. In the sleep scheduling approach, the node takes the decision for their states independently in decentralized manner. Using this reward based approach; the node decides its own current state (sleep, wake, idle) and it also predict the state of neighbors without communicating with neighbors. The performance improvement of sleep scheduling algorithm is significant but, to enhance performance it should be integrated with clustering approaches. To support the mobility in wireless sensor network various MAC protocol has been proposed, but they consume huge energy for data transmission. The proposed MACRON algorithm works efficiently in both mobile and stationary network. The performance of proposed algorithm gives decent outcome in varying size of nodes ranging from 10 to 40 in ns-2.*

***Index Terms**: MAC, AODV, TDMA, sleep/wake-up, MEMAC, RIMAC, Wireless Sensor Network, Energy-efficient Algorithm, Cross-layer Protocols*

I. INTRODUCTION

To send packet from source node to destination node in wireless environment, multi-hop routing algorithm is used. The packet will be transmitted to sink via routing algorithm. The difficulty with conventional routing approach is uneven energy consumption and redundant data transmission. Conventional Wireless sensor network mainly focuses on statically deployed Nodes. The recently deployed network is very dynamic and complex now a day. To announce the presence, node broadcast its mobility state and collects the neighboring information at fixed interval. Therefore, the movable node should update the routing table to avoid transmission from damaged connection. In addition, the moveable node should be coordinated to use the same active/idle schedule as its new neighbors for the assurances of data transmission when it moves. In recent times, very few MAC protocols supports dynamic nature of nodes like moving from one cluster to another, battery drain and many more. Therefore, maintaining the connection with Cluster head and neighboring nodes while keeping energy consistency is key concern in design of routing protocol and it need to be study in depth. This paper proposes a cross layer approach of Mobility Aware Clustering approach with reward-based sleep scheduling approach.

The MAC protocol is classified as Contention based, scheduled based and hybrid based protocols as shown below in fig. 1.

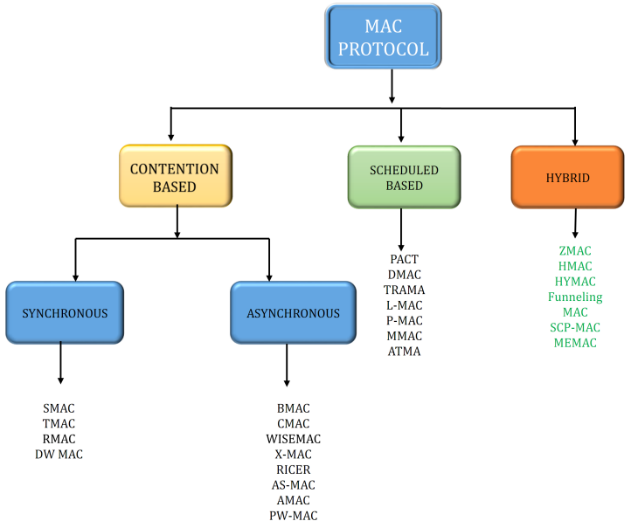

Figure 1. Classification of MAC Protocol

The hybrid combination of contention based and scheduled based MAC protocol improves the efficiency of overall system and provides good results to improve the lifetime of sensor network.

II. PROPOSED SYSTEM

The most frequent demand of wireless sensor network is to enhance the network by adding , shifting or deleting the new or existing node. Due to this the chances for failure of nodes will be increasing. To handle the dynamic changes in wireless network MACRON offers conflict based and scheduled based strategies. MACRON is derived from MAC, MEMAC and conventional sleep scheduling to overcome the drawback of the various algorithms. SEHM algorithm proposed by Bashir and Jalel [2] in which Hybrid scheme for MAC Protocol has been applied. Here to handle the scalability of WSN the cluster heads are created but it it needs two step method, which is time consuming and introduce overhead in sensor network. This algorithm has not introduced any mechanism to handle the dynamicity of nodes.

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This is the one direction in which MACRON differs from SEHM.MEMAC has devised the strategy to decide the frame length as per the mobility of nodes in sensor network this will introduce the length control messages and improve the lifetime of network. This is another direction which is adopted by MACRON to improve the performance algorithm.

The Mobility Aware Clustering Routing Algorithm (MACRON) is proposed in this paper twofold mechanism of Clustering based MEMAC and Scheduling are integrated. To enhance the energy efficiency of network, MEMAC distinguish between cluster head (data nodes) and idle nodes. To eliminate the overhead of data transmission, the data node only will take participate in data communication. For scheduling of node communication the self - adaptive approach is adopted in MACRON algorithm. Here the time is divided into slots and each node is allowed to take its own decision for sleep, listen and transmission. Each node takes the decision by observing the individual and its neighbor's current situation. This observation eliminates the data transmission between the node of interest and its neighbors and overhead of data transmission will be reduced. Till now many researcher has proposed numerous algorithms to deal with these two approaches individually, but the combined scheme is not proposed yet. So the objective of this paper is to propose the integrated approach MACRON for enhancing the performance of sensor network.

A. *Network creation*

In traditional sensor network if any node wants to communicate with any other node. Sender node first create the link with its neighbor node and so on; out of this connection it will create the straight link to reach to destination then it will transmit the packets. Because of some disadvantage of this traditional method this system falling to obtain energy efficiency and degrade the lifetime of network. So MACRON is proposed to overcome this limitation.

B. *Cluster Creation*

In WSN, there's 'n' number of nodes. In the event that nodes fall flat, it turns out to be extremely hard to locate the specific node 512. For that, we make a set of nodes. Because of this, failure node discovery will turn out to be simple. In Figure 2, there are four clusters wherein all nodes are named. Node 1 attempt and send records to Node 16. The majority of the distinctive nodes are middle nodes or supporting nodes who ahead approaching bundles to some other ensuing node in some other cluster. The cluster will shape in light of closest neighbour strategy.

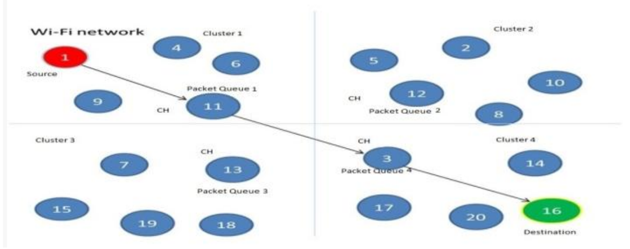

Figure 3: Modified Routing using Mobility Aware Clustering Routing algorithm (MACRON)

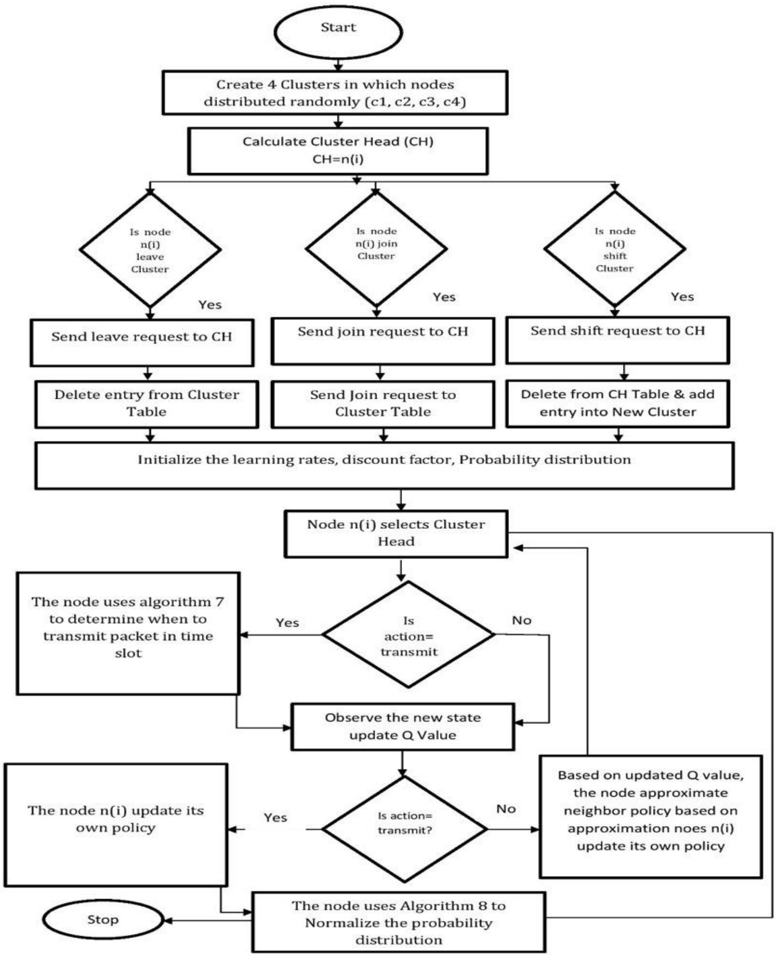

Figure 2. Proposed schema for Mobility Aware Clustering Routing algorithm (MACRON)

Algorithm 1: Cluster Creation for a node

1. let N be the total no of nodes.
2. form 4 Random size clusters $C_1, C_2, C_3, , C_4$
3. if node $nd(i)$ in the same hyper plane

   add node $nd\ (i)$ to the nearest cluster $C\ _i$
   where $nd\ (i) \in\ N\ \&i\ = 1, 2, 3, 4.$
4. update Routing Table R.
5. end.

C. *Head Calculator*

Clusters Head created with admire to cluster quantity phase-on this segment CH circulate the calculated plan to the opposite node within a cluster 312. The schedule carries the one's nodes which have data to send only. The present-day schedule does no longer consider nodes that want to leave or join the cluster. If the scope of the request message is larger than a number of joins or leave messages, then frame duration is increased otherwise reduced.

MEMAC convention to choose cluster head in MACRON where time is separated into rounds and just a single node is cluster head (CH) for a given round. At first likelihood, $prob$ is used to choose CH which communicate its choice. Each non-CH node decided cluster by choosing CH that can be achieved utilizing minimum correspondence vitality. To ration vitality and adjust the heap the responsibility of cluster head is pivoted among CH. The turn is performed by acquiring every node to pick an arbitrary number "T" in the proximity of 0 and 1. A node turns into a CH for the present pivot round if the number is not as much as the accompanying limit:

$$T(n) = \frac{prob}{1 - prob\left(ronum * mod\ \frac{1}{prob}\right)} * \frac{E_{curr}}{E_{init}}, if\ n\ \in G$$

$$T(n) =\ 0, otherwise$$

------- (1)

Where n is the given node, $prob$ is the earlier probability of a node being chosen as CH, $ronum$ is present round number, current will be present vitality if the node E initial is starting vitality of the node. Furthermore, G is the arrangement of that node which not being chosen as CHs in the last $\frac{1}{prob}$ rounds. The round $ronum$ is characterized as

$$ronum\ = k\ * cl$$ -------- (2)

where cl is the casing length, and k is a number variable more noteworthy than one, the no of cluster head is said to 5% of the aggregate sensor nodes.

An available cluster head node failed then next cluster head CH browsed accessible nodes in the cluster which was not picked before as a cluster head. The accompanying pseudocode demonstrates to calculate cluster head.

Algorithm 2: Cluster Head Calculation

1. let nd is the node and CH be cluster head
2. if node $nd(i)$ wants to become CH
3. find Probability $prob$.
4. get Current Energy of node E_{curr}
5. get Current Energy of node E_{init}
6. evaluate $ronum$ by using equ (2).
7. compute $T(n)$ **by** using $equ(1), \forall n\ \in i$
8. else $T\ (n)\ = 0$
9. find $T_{max}(k) = Max(T(n))$,from all calculated set of $T(n), \forall C_j$, where $k\ = 1,2,3,4$
10. new elected $CH\ = nd\ (i) \in\ C\ (j)$

    $whose\ T\ (n) = Tmax, \quad \forall\ C\ (j).$
11. broadcast list of new $CH = \{ch_1, ch_2, ch_3, ch_4\}$,$\forall\ C_j$
12. end

D. *Leave / Join scheduling*

In case of the request or leave phase, contention period should be long enough to enable all sensor node 112. The Channel access is handled in mobility aware MAC protocol in following stages: leave\join phase, schedule scheming and distribution phase and data transfer stage. In case of request or leave phase the conflict period should be long enough to enable all sensor nodes that have data to transmit contain for the channel in order to acquire access to send its request to CH, as well as those nodes which are expected to leave or join the cluster, should inform the CH by sending message of leave or join. The leave join actions are depending upon sleep-wakeup cycle as well. Sometime if any node may go in long sleep cycle would be considered as a join operation and also during wakeup node will transmit join message info to CH.

Case 1: Leave activity of Node

Any of the existing node from cluster may leave the cluster due to any reason like low energy problem or to shift into another cluster will follow the algorithm (3).

Algorithm 3: Leave activity of node

1. let N be the nodes in cluster C_j.
2. if node $nd\ (i)$ wants to leave cluster C_j
3. send 'LEAVE' request to CH_j
4. CH will accept the request.
5. CH will update routing table R.
6. for $node\ nd(i)$
7. status $(nd\ (i))\ = leave.$
8. acknowledge the node $nd(i)$.
9. end
10. node $nd(i)$ will terminate the connection
11. end.

Case 2: Join activity of Node

The new node may join the desired cluster by sending the JOIN request as mentioned in algorithm (4), and new entry will make for same node in other cluster's routing table which may start sending or receiving data in WSN. The flow for Join activity of CH is below:

Algorithm 4: Join activity of node

1. let N be the nodes in cluster C_j
2. if node $nd\ (i)$ wants to join the cluster C_j
3. send 'JOIN' request to CH_j
4. accept request from CH_j
5. update routing table R for CH_j
6. for node $nd(i)$

7. status $(nd(i)) = join$
8. acknowledge the node $nd(i)$.
9. end
10. node $nd(i)$ will activate the connection
11. end.

Case 3: Shift activity of a node.

A node from one cluster goes into another cluster or we can say that leave one cluster and join other cluster then shift operation will performed 112. In this, CH delete entry from current cluster and make entry into latest cluster. Shift operation is combination of leave and join activity.

Algorithm 5: Shift activity of a node.

1. let N be the nodes in cluster C_i
2. if node $nd(i)$ wants to shift the cluster C_i to C_j
3. send 'LEAVE' request to CH_i
4. CH_i will accept the request.
5. status $(nd(i)) = leave$.
6. CH_i will delete entry from routing table $R(j)$.
7. send 'JOIN' request to CH_j
8. CH_j will accept the request.
9. status $(nd(i)) = join$.
10. CH will make entry in routing table $R(i)$.
11. update the entry of Node $nd(i)$ in cluster C_j
12. end

Case 4: Sleep-wake up activity of node

If all nodes in WSN are activated all the time, it spends more energy on the network [7]. It comprises idle nodes as well as active nodes. In on-demand wake-up approach, the node is inactive for 10 seconds then it will go into inactive state and after 60 sec it wakes up for activity [10][11][13]. If is there any activity for that node, it completes that activity and wait for 10 sec and so on. The Pseudo code of on-demand wake-up approach is as follows:

Algorithm 6: sleep/wake up scheduling of a node

let lr_1 and lr_2 are two learning rates, $dsft$ is discount factor, A is set of n available action $\{a_1, a_2, \dots, a_n\}$, $a_i \in \{trans, sleep, idel\}$, s_{curr} is current state of action of interest, s_{next} is next state of action of interest

1. for each iteration of each action $a_i \in A$
   define value function $Q_i := 0$
   define rule $\gamma := \frac{1}{n}$
2. Repeat
3. according to the rule $\gamma\,(s_{curr}, a_i)$ select an action a_i of s_{curr}
4. if the selected rule $a_i := trans$
5. node decides time slot to transmit the packet
6. detect payoff ∂ and s_{next}
7. update Q_i

$$Q_i(s_{curr}, a_i) \leftarrow (1 - nr_1)Q_i(s_{curr}, a_i) + nr_1\,(\partial + nr_2 \max\,(s_{next}, a_{i+1}))$$

8. if the selected action $a_i \neq sleep$
9. in the current timeslot, neighbour is interacting with the node on the basis of Q_i, approximation rule
10. update the policy of current node $\gamma\,(s_{curr}, a_i)$ based on approximation rule $\forall a_i \in A$
11. else
12. calculate the average payoff ∂_{avg}
13. $\bar{P}\,(s_{curr}) \leftarrow a_i \in A\,\gamma\,(s_{curr}, a_i)\,Q\,(s_{curr}, a_i)$
14. for $\forall a_i \in A$ do
15. $\gamma\,(s_{curr}, a_i) \leftarrow \gamma(s_{curr,} a_i) + lr_2\,Q(s_{curr,} a_i) - \bar{P}(s_{curr})$
16. $\gamma\,(s_{curr}, a_i) \leftarrow \text{Normalise}(\gamma\,(s_{curr})$
17. $nr_1 \leftarrow \frac{k}{k+1} * nr_1$
18. $s_{curr} \leftarrow s_{next}$
19. until the process is terminated;

Algorithm 7: Node Determines When to Transmit a Packet in Time Slot

Let lr_1 and lr_2 are two learning rates, sub-slot s_{slot} and current time slot t_{slot},m is the number of sub slots , Consider the set of sub-slots $S = \{s_1, s_2, \dots, s_m\}$, $probx(i)$ is probability for selecting the sub-slot,

1. For each $s_{slot} \in t_{slot}$
2. define value function $Q_i := 0$
3. $probx(i) = \frac{1}{\mathrm{m}}$
4. select s_{slot} in t_{slot} based on the $probx(i)$ over $S = \{s_1, s_2, \dots, s_m\}$,
5. observe payoff ∂
6. update Q_i

$$Q_i \leftarrow Q_i + s_i * lr_1 * prob - \sum_{1 \le i \le m} s_i\,Q_i$$

7. update s_i for each sub-slot s_{slot}

$$s_i = \begin{cases} (1 - lr_2) + \left(\dfrac{lr_2}{m}\right), if\ Q_i\ is\ the\ maximum \\ \left(\dfrac{lr_2}{m}\right), otherwise \end{cases}$$

8. $S \leftarrow$ Normalize(s);

Algorithm 8: Normalize ()

let c_m is mapping center and θ is mapping lower bound

1. consider m actions $\{a_{1,} a_{2,\dots}\ a_m\}$ are performed in state s
2. let $\mu = \min_{1 \le k \le} \gamma(s, a_{k,})$, c_m=0.5 and θ =0.001
3. if $\mu < \theta$ then
4. $\tau \leftarrow \frac{c_m - \theta}{c_m - \mu}$
5. for $k := 1$ to m do
6. $\gamma(s, a_k) \leftarrow c_m - \tau \cdot (c_m - \mu(s, a_k)$
7. for k=1 to m do
8. $r \leftarrow \sum_{1 \le k \le m} \mu(s, a_{k)}$
9. $\mu(s, a_{k)} \leftarrow \frac{\mu(s, a_{k)}}{r}$
10. return $\mu(s)$;

III. SIMULATION RESULTS

In the proposed system variation of 10-40 Nodes simulation scenario, MACRON is compared RI-MAC, ATMA, AODV and MEMAC. This system compares various Quality of service aspects such as average delay calculation, PDR, Energy utilization, Hop count, SNR, RSS, Mean calculations, throughput calculation etc.

Table 1: Results for Delay Calculations

Number of nodes	Average end to end delay (ms)				
	RI-MAC	ATMA	AODV	MEMAC	MACRON
10	5.551	3.265	0.4	0.15	0.40670886
20	7.618	4.989	1	0.21	0.40898305
30	9.697	4.587	2.5	0.25	0.41358974
40	9.577	5.314	3.5	0.28	0.42789474

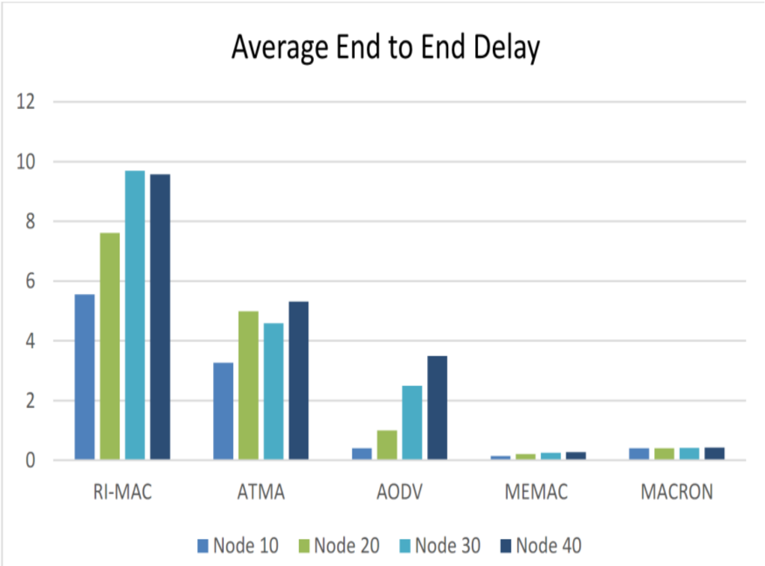

Fig. 4 Graphical representation of RIMAC, ATMA, MEMAC, MACRON and AODV

Table 2: Results for Packet Delivery Ratio

Number of nodes	Packet delivery ratio (PDR) (%)				
	RI-MAC	ATMA	AODV	MEMAC	MACRON
10	97.085	99.87	99.58	99.84	99.93
20	97.33	99.87	98.42	99.77	99.91
30	96.53	99.7	97.37	99.73	99.86
40	95.03	99.38	96.32	99.7	99.72

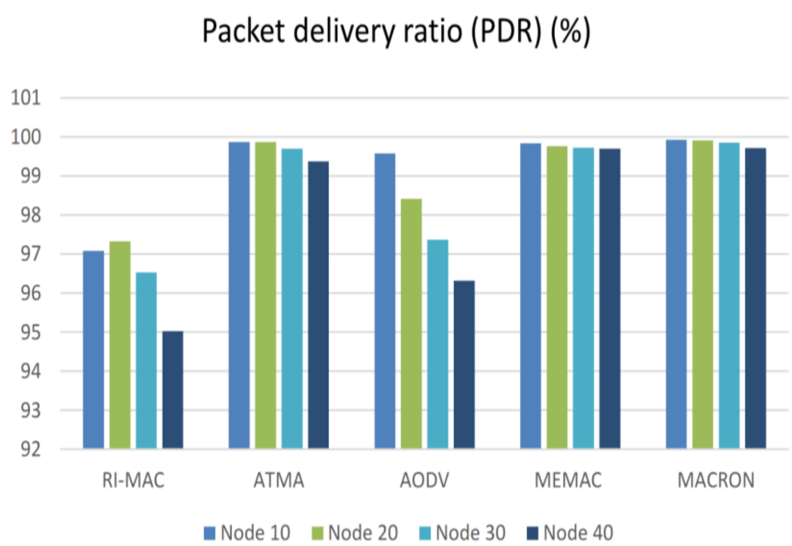

Fig. 5 Graphical representation of RIMAC, ATMA, MEMAC, MACRON and AODV

Table 3: Results for Average throughput

Number of nodes	Average throughput (Kbps)				
	RI-MAC	ATMA	AODV	MEMAC	MACRON
10	0.78	0.97	10	6.15	9.93
20	2.06	1.96	10	5.79	9.91
30	2.93	2.94	20	7.27	9.86
40	3.87	4.23	30	7.69	9.72

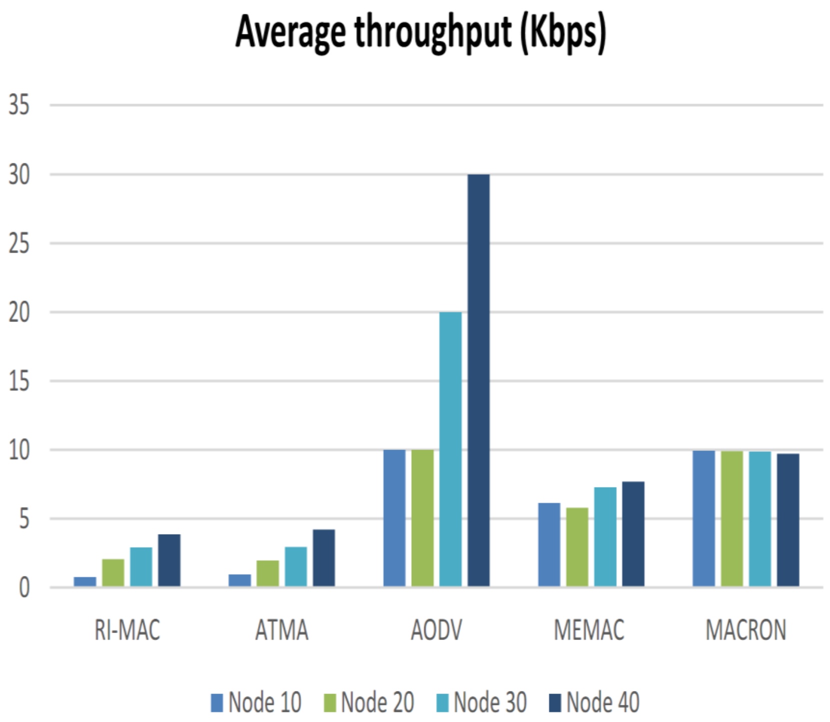

Fig. 6 Graphical representation of RIMAC, ATMA, MEMAC, AODV and MACRON

Table 4: Results for Energy Consumption

Number of nodes	Average energy consumption (mJ)		
	RI-MAC	ATMA	MACRON
10	77	117	74.52830189
20	190	114	55.66037736
30	312	137	36.79245283
40	402	147	17.9245283

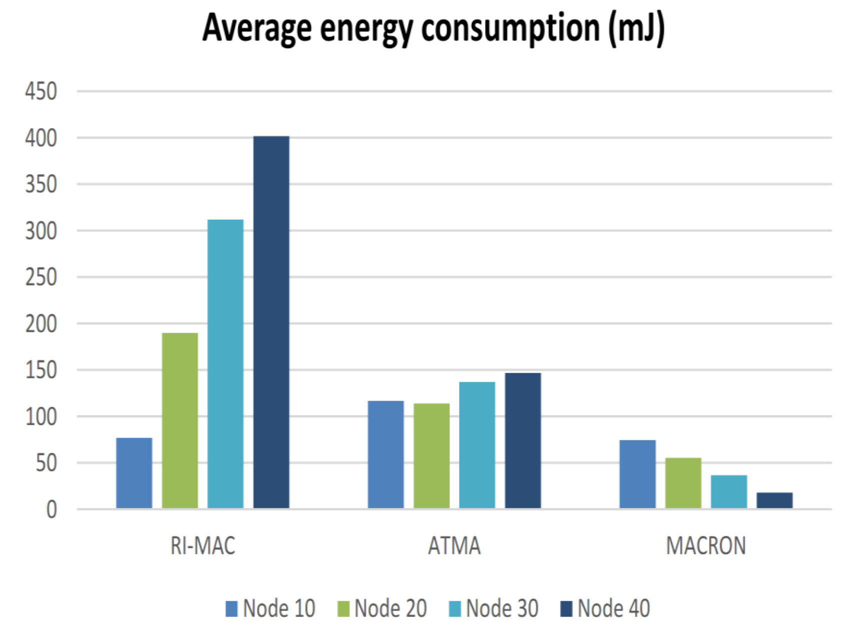

Fig. 7 Graphical representation of RIMAC, ATMA, MACRON

Table 5: Simulation results for MEMAC, MACRON and AODV

Number of nodes	SNR(db)		
	AODV	MEMAC	MACRON
10	168.1293	3	3.555696203
20	211.9027	5	4.761016949
30	232.1759	23	7.202564103
40	246.5601	29	14.78421053

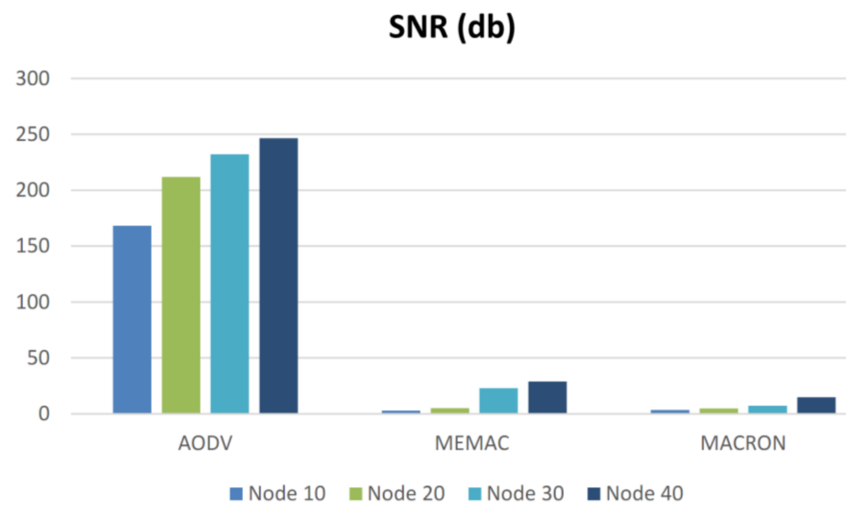

Fig. 8 Graphical representation of MEMAC, MACRON and AODV

Table 6: Results for Hop Count

Number of nodes	Hop count		
	AODV	MEMAC	MACRON
10	3	6	2
20	19	7.4	2
30	28	5	2
40	38	5	2

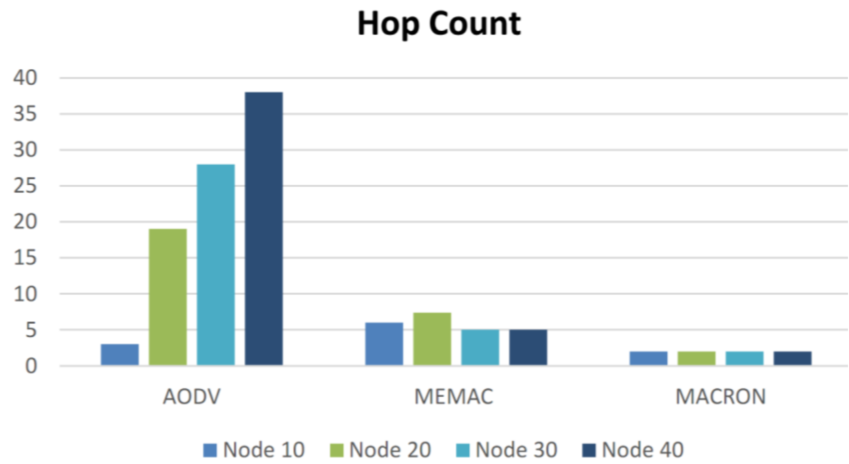

Fig. 9 Graphical representation of MEMAC, MACRON and AODV

Table 7: Results for Received signal strength

Number of nodes	RSS in DB		
	AODV	**MEMAC**	**MACRON**
10	113.129255	-48	10.6
20	156.902692	-56	10.6
30	177.175947	-28	10.6
40	191.560051	-22	10.6

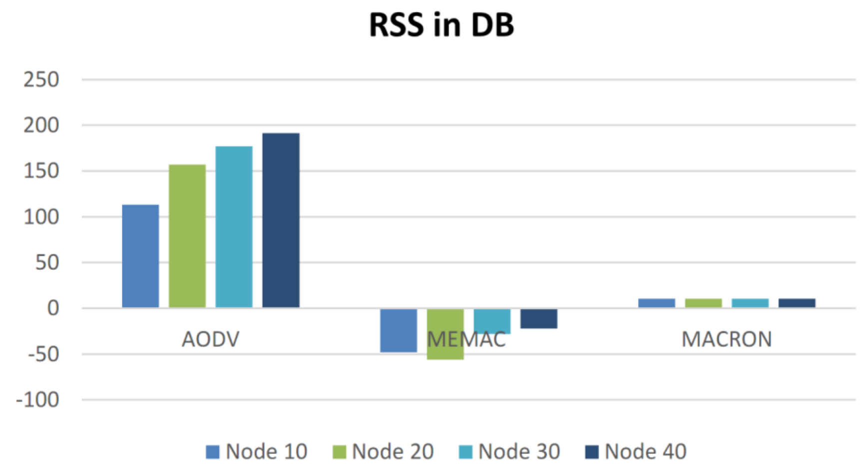

Fig. 10 Graphical representation of AODV, MEMAC and MACRON

Table 8: Results for Mean Deviation

Number of nodes	Mean Deviation		
	AODV	**MEMAC**	**MACRON**
10	200	197.5	13.41772152
20	220	197.1	17.96610169
30	230	198.5	27.17948718
40	240	198.8	55.78947368

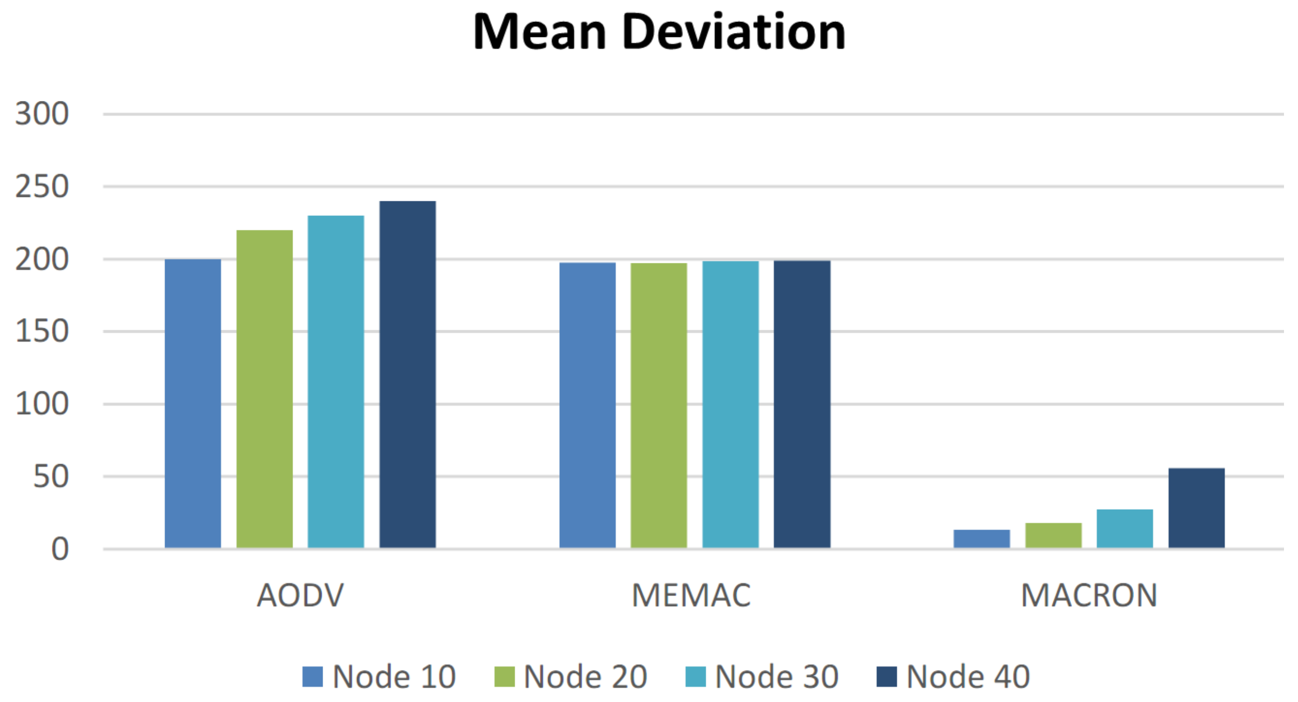

Fig. 11 Graphical representation of MEMAC, MACRON and AODV

IV. CONCLUSION

For improvement in overall life of sensor network many hybrid combinations of MAC protocols has been proposed. Almost all protocols are giving good results individually but the cross layer combination of MAC with routing protocol gives better result for improving lifetime efficiency. This paper shows comparative analysis of MACRON with RIMAC, AMTA, AODV and MEMAC. For the several set of nodes ranging from 10 to 40, the performance of MACRON is analysed for delay calculations, SNR, throughput calculations, hop count, received signal strength, mean deviation and energy utilization on client side and server side. The outcome of simulation shows that MACRON outperforms RIMAC, ATMA, AODV and MEMAC.

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