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Optimizing MAC Layer Performance based on Machine learning with Localized AI

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Abstract: Energy consumption, end to end communication delay, jitter in delay, the packet delivery ratio (PDR) and communication throughput are the primary parameters which define the performance of any Medium Access Control (MAC) layer used in wireless communication systems. Optimization of these key parameters is the main aim of any network designer. In this paper, we propose machine learning based Artificial Intelligence (AI) approach for improvement of the mentioned parameters using localized learning. Localized learning ensures that all the network learning is done locally on the node, and there are no privacy issues in the network. The proposed AI based algorithm takes into consideration the network parameters and suggests a solution which is best suited in order to optimize the mentioned primary output performance parameters. The AI layer incorporates the use of Time Division Multiple Access (TDMA), Bit Map Assisted (BMA) and Sensor-MAC (SMAC) protocols, and by tuning the parameters of these protocols; suggests the best tuned protocol suited for the given network conditions. We tested the system under various network configurations and obtained an overall performance uplift of more than 20% across all the output key parameters.

Keywords: Artificial Intelligence (AI), BMA, Energy Efficiency, MAC, SMAC, TDMA, Localized learning

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1. Introduction

Medium Access Control (MAC) layer is responsible for packet transfer between various communication devices. In most cases, the efficiency of designing the MAC layer defines the overall efficiency of the entire communication protocol stack. Researchers have tried to optimize the performance of the existing MAC layer for minimizing communication delay, optimizing network lifetime and improving the scheduling of packets. One of the most common design algorithms to optimize the usage of MAC layer is Time Division Multiple Access (TDMA) protocol. The TDMA protocol [1, 2, 3, 4], defines how the network packets can be transferred from one node to another in a time sharing manner. In TDMA, all the nodes share a common resource which can be a particular channel, or a particular central node, and then decide a time sequence for accessing this common resource, so that each of the nodes can get an equal share of using the resource based on the node's requirements.

TDMA is good as a primary technique for modelling the MAC layer, but it has a latency issue. Using TDMA for large number of nodes has an inherent issue that the nodes need to wait for longer durations to access the shared resource. Clustering solutions are often combined with TDMA-based schemes to reduce the cost of idle listening. TDMA-based schemes cannot change the time slot allocations and frame lengths dynamically according to the unpredictable variations of sensor networks. Thus, to overcome these issues researchers suggested the Bitmap Assisted (BMA) MAC protocol [5, 6, 7]. BMA is an intra-cluster communication bit-map-assisted (BMA) MAC protocol for large-scale cluster-based WSNs. It is intended for event-driven applications, to reduce energy consumption due to idle listening and collisions and change dynamically according to the variations of networks. The operation of BMA is divided into rounds. Each round consists of a cluster set-up phase and a steady-state phase. In the cluster setup phase, the node decides whether it could become a cluster head based on its energy level while, the cluster head broadcasts an advertisement message to all other nodes claiming to be the new cluster-heads. The steady state phase is divided into k sessions where, each session consists of a contention period, a data transmission period and an idle period. During the contention period, the node transmits a 1-bit control message during its scheduled slot if it has data to transmit while the cluster head sets up and broadcasts a transmission schedule for the source nodes. During the Data Transmission Period, the source node sends its data over its allocated slot-time, and keeps its radio off at all other times, and the non-source nodes have their radios off during the data transmission period. This saves an ample amount of energy which is otherwise consumed by the idle nodes in TDMA, thus improving the energy efficiency and lifetime of the network.

Another MAC protocol directed towards sensor networks is termed as Sensor MAC or SMAC protocol [8, 9, 10, 11]. Usually packet collision, overhearing, Control packet overhead and idle listening are the 4 sources causing energy inefficiency in the sensor networks. SMAC tries to reduce wastage of energy from all four sources of energy inefficiency. It reduces collision by using RTS and CTS, Overhearing by switching the radio off when transmission is not meant for that node, Control Overhead by message passing and idle listening by periodic listen and sleep. While

SMAC has some reduction in per-hop fairness and latency but it does not reduce end-to-end fairness and latency. SMAC is composed of many small nodes deployed in ad hoc fashion. Most communication using SMAC will be between nodes as peers, rather than a single base station thus the nodes must self configure. SMAC has the following three components:

Periodic listen and sleep

Collision and Overhearing avoidance

Message passing

In periodic listen and sleep, each node goes into periodic sleep mode during which it switches the radio off and sets a timer to awake later. When the timer expires, it wakes up. Selection of sleep and listen duration is based on the application scenarios, for high speed applications this duration is less while for low power scenarios this duration can be increased. Neighbouring nodes are synchronized together in order to make sure there is no energy wastage. To do this, Nodes exchange schedules by broadcast where multiple neighbours contend for the medium. Once the medium is assigned, and the transmission starts, it does not stop until completed. For collision avoidance, a mechanism similar to IEEE 802.11 using RTS/CTS is used which performs virtual and physical carrier sense before transmission. RTS/CTS addresses the hidden terminal problem as well, while NAV indicates how long the remaining transmission will be continued before transfer is given to other nodes. This also addresses the overheating problem by making sure that interfering nodes go to sleep after they hear the RTS or CTS packet, the medium is kept busy when the NAV value is not zero and all immediate neighbours of sender and receiver should go to sleep. For message passing, the message is divided into small fragments which have a high control overhead but the message passing is efficient.

Our proposed technique uses a combination of all the mentioned techniques, and applies a machine intelligence layer to it in order to improve the overall efficiency of the wireless network. The next section describes some the standard MAC protocols which were studied before proposing our AI and machine learning based algorithm. Post that our algorithm is described, and then it's results are compared with standard techniques in terms of primary network parameters. We then conclude the text with our observations about the proposed protocol and how other researchers can improve the protocol further.

2. Literature Review

Research scholars and wireless network designers have proposed many MAC protocols like TDMA, BMA, SMAC and others. Simpler protocols like ALOHA [12], Slotted ALOHA [13], Dynamic ALOHA [14], Mobile slotted ALOHA [15], CDMA [16], OFDMA [17], CSMA [18], CSMA/CD [19] have also been proposed by researchers in order to improve the overall network performance of the MAC layer. The medium access (MAC) layer is not important on point-to-point links but is only used in broadcast or shared channel networks. MAC protocols enable two stations (or nodes) using a shared communication resource to establish, maintain and terminate a connection. MAC layer techniques can be divided into,

- Synchronous

A specific capacity is dedicated to a connection

Same approach as in circuit-switching FDM or TDM, so not optimal for LANs/MANs because the needs of the stations are unpredictable

- Asynchronous

Capacity is allocated in a dynamic fashion, in response to demand.

Subdivided into three categories

- Round Robin
- Reservation
- Contention

While synchronous techniques are relatively simpler, the asynchronous techniques are very complex and are divided into the following sub categories:

- Round Robin based

Each station in turn is granted the right to transmit.

After each station finishes transmitting, it passes the right to transmit to the next station in logical sequence.

Efficient technique when many stations have data to transmit over an extended period of time.

- Reservation based : For stream traffic (voice, bulk file transfer etc).

Time on the medium is divided into slots, like synchronous TDM. A station wishing to transmit reserves slots for an extended period.

- Contention based

For busty traffic (short, sporadic transmissions such as interactive terminal-host traffic).No control is exercised to determine whose turn it is Simple to implement and efficient for light loads.

Protocols like ALOHA comes under asynchronous techniques for MAC implementation, and is fairly simple to implement. The ALOHA protocol is also called as "Free for

International Journal of Scientific & Engineering Research, Volume 9, Issue 5, May-2018
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all": whenever station has a frame to send, it does so. Station listens for maximum return time for an acknowledgement signal (ACK). If no ACK is received, then it re-sends frame for a number of times and then gives up. Receivers check source address and destination address to send ACK. Collisions are a major drawback of ALOHA, which may be caused by channel noise or because other station(s) transmitted at the same time. Collision happens even when the last bit of a frame overlaps with the first bit of the next frame. Slotted ALOHA improves on the performance of ALOHA by allowing transmissions only in slots, which reduces some collisions but still the network performance is not good. All other ALOHA techniques suffer from one or other drawback, and are not used in practical network scenarios. The capacity of ALOHA based techniques is limited by the large vulnerability period of a packet. By listening before transmitting, stations try to reduce the vulnerability period to one propagation delay. This is the basis of CSMA. In CSMA, the station that wants to transmit first listens to check if another transmission is in progress (carrier sense). If medium is in use, station waits; else, it transmits. Here, the transmitter waits for ACK; if no ACKs, then only it retransmits. Collisions can occur only when 2 or more stations begin transmitting within short time. If one station transmits and there are no collisions during the time of the leading edge of frame, then the frame propagates to farthest station hence no collisions. The CSMA improves widely on the performance of ALOHA, thus was adopted widely by researchers. The following are the different modifications of CSMA:

- 1-persistent CSMA (IEEE 802.3)
  - If medium idle, transmit; if medium busy, wait until idle; then transmit with p=1.
  - If collision, waits random period and starts again.
- Non-persistent CSMA: if medium idle, transmit; otherwise wait a random time before re-trying.
  - Thus, station does not continuously sense channel when it is in use.
- P-persistent: when channel idle detected, transmits packet in the first slot with p.
  - Slotted channel, i.e., with probability q = p-1, defers to next slot.

The following graph shows the performance comparison of ALOHA when compared with other CSMA based techniques,

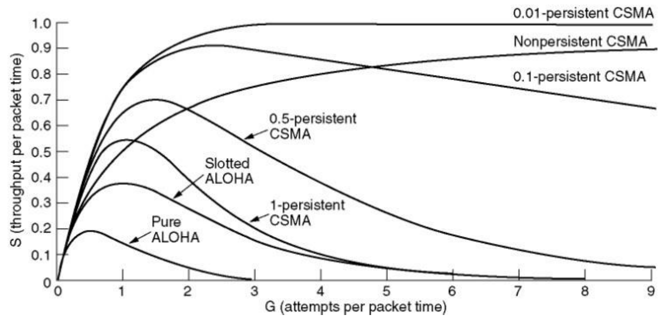

Figure 1: Comparisons of CSMA based techniques

The TDMA protocol improves the performance of the ALOHA, CSMA and other variations of the protocols by allotting fixed time slots to each of the communicating nodes, thereby improving the capacity of the overall system, and thus it is the base of our research. It is improved by using BMA which is further improved by using SMAC in sensor networks.

It is discovered that the lifespan of at random Distributed wireless sensing element networks gets accomplished due to the unbalanced energy consumption in sensing element nodes. The energy consumption is balanced among sensing element nodes by exploitation the economical clump rule that's projected in [20]. There MAC unit two cluster sections of EECS, one is setup section and another is steady state phase. The cluster election rule selects cluster head that uses sensing element nodes native data. Within the steady state section, the time slots MAC unit assigned for member nodes as per the information that is out there in sensing element nodes. As compared to SA-EADC and EADC, the simulation results of EECS is healthier once viewed in consumption of energy and lifelong of a network. In real time networks, optimizing a good wireless sensing element network to increasing the lifespan of sensing element node so as to attenuate energy resource and maximize overall system performance becomes vital. The energy consumption is especially determined by the selection of media access mechanism. Sensor-MAC could be a typical access mechanism that has drawn a lot of attention in recent years regarding minimizing answer energy resource [21]. In S-MAC, a border node is found the smallest amount of two virtual clusters, every virtual cluster has personal sleep timer, listen timer, wake-up timer. Border nodes will listen additional schedules than different nodes, so that they have to be compelled to have additional energy consumption that create their power to consume quicker, to have an effect on to take care of productive purpose data. The author of [21], propose an answer technique regarding energy potency once nodes add its correct data to their list schedules that solely implement one schedule later.

Other MAC protocols additionally contain self organizing techniques for improved performance as mentioned in [22]

International Journal of Scientific & Engineering Research, Volume 9, Issue 5, May-2018
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the researchers gift an ad-hoc design for wireless sensing element networks and different wireless systems the same as them. During this category of wireless system the physical resource at premium is energy. Information measure out there to the system is in way over system needs. The approach to unravel the matter of ad-hoc network formation here is to use out there information measure so as to avoid wasting energy. The tactic introduced solves the matter of connecting an ad-hoc network. This rule offers procedures for the joint formation of a time schedule (similar to a TDMA schedule) and activation of links in that for random network topologies. This organization technique is energy-sensitive, distributed, scalable, and ready to type a connected network apace. In [23] the developed MAC protocol minimizes the energy overhead of idle time and collisions by strict frame synchronization and slot reservation. It combines a dynamic information measure adjustment mechanism, multicluster-tree topology, and a network channel permitting speedy and low-energy neighbour discoveries. The protocol achieves high measurability by using frequency and time division between clusters. Performance analysis shows that the MAC protocol outperforms current progressive protocols in energy potency, and therefore the energy overhead compared to a perfect MAC protocol is simply 85% to 27.1%. The high energy potency is achieved in each leaf and router nodes. The models and therefore the practicability of the protocol were verified by simulations and with a complete model implementation. Whereas a number of the protocols MAC unit supported cooperative or allocation theme, some MAC unit supported competitive theme, et al. MAC unit on the inspiration of hybrid theme. However, it's still troublesome to boost the energy potency and networks turnout at the same time. In [24], the researchers gift a completely unique CSMA/CA and TDMA hybrid theme protocol (CTh-MAC) on MAC layer to boost the turnout and cut back energy consumption at a similar time for mobile WSN with position prediction rule. Examination to existing protocols, the projected protocol will with efficiency cut back the energy consumption and considerably improves the turnout, particularly for high-speed mobile WSN in many-to-one communication paradigm. Intensive simulation results prove the performance of the protocol.

Traffic adaptation is required for duty cycle optimisation, so in [25] the researchers gift a traffic-adaptive synchronous MAC protocol (TASMAC) that could be a high-throughput, low-delay MAC protocol tailored for low power consumption. It achieves high turnout by adapting time division multiple access (TDMA) to a completely unique traffic-adaptive allocation mechanism that assigns time slots solely to nodes placed on active routes. TAS-MAC reduces the end-to-end delay by notifying all nodes on active routes of incoming traffic before. These nodes can claim time slots for information transmission and forward a packet through multiple hops during a cycle. The fascinating traffic-adaptive feature is achieved by mouldering traffic notification and data-transmission programming into two phases, specializing their duties and raising their potency, severally. Simulation results and experiments on TelosB motes demonstrate that the two-phase style considerably improves the turnout of current synchronous MAC protocols and achieves the similar low delay of slot-stealing-assisted TDMA with a lot of lower power consumption. AN improvement to TDMA is shown in [26], wherever the researchers gift ED-TDMA, AN event-driven TDMA protocol for wireless sensing element networks. Then we tend to conduct intensive simulations to match it with different MAC protocols akin to BMA, S-MAC, and LMAC. Simulation results show that ED-TDMA performs higher for event-driven application in wireless sensing element networks with high-density preparation and beneath low traffic. The next section describes our proposed algorithm in detail followed by the results and observations in our approach when compared to standard protocols.

3. Machine learning and AI based MAC with localized learning (MLAiLLMAC)

Machine learning has been a state of the art technique for optimizing algorithms for various fields including but not limited to image processing, signal processing, digital communication and network routing among many others. Our proposed machine learning and AI based technique with localized learning uses the core concepts of machine learning namely Q-learning and trains the node locally in order to maximise the efficiency of the overall network. Q-learning is a Reinforcement learning technique which learns behaviour through trial-and-error interactions from a dynamic environment, and determines the actions by the experience built up from rewards and punishments [27]. The Q Learning algorithm is as follows:

1. A solution is a state; the action is whether to keep the solution or discard it, and the reward is the learning metric value.
2. When a solution is generated, the learning metric is evaluated based on the formula given.
3. This LM is compared with the previous LMs (Q Learning).
4. Based on these findings we discard or accept the solution in order to get the optimized solution (re-enforcement learning task).

International Journal of Scientific & Engineering Research, Volume 9, Issue 5, May-2018
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Algorithm : MAC layer optimization Algorithm

Input : 1. Number of solutions (Ns) = 20
2. Number of rounds (Nr) = 20
3. Learning convergence (Lc) = 0.8
4. Max nodes per solution (Nmax) = 3
5. Link quality (Lq) = 0.5
6. Learning Threshold Factor = 0.5

Output : Best path & protocol for communication.

1. Select a source and destination src and dest
2. Find the reference distance between the nodes (dref)
3. For each solution,
   a. Find the number of nodes
      (N) = random value * Nmax
   b. Select N random nodes between source and destination, meeting the following condition,
      dis + did >= dref
      and, dis<dref & did < dref
      where, dis = Distance between the current node and source
      did = Distance between the current node and destination
   c. Evaluate the Learning Metric (LM),
      LM=Sum(Di,i-1 / Ei-1+1/LQ(i,i-1))
      where,
      Di,i-1 = Distance between the selected nodes i and i-1
      Ei-1 = Energy of the i-1th node
      LQ(i,i-1) = Link quality between ith and i-1th node
4. Find the mean of all the LQ values (LMean), and then evaluate learning threshold (Lth), as follows,
   Lth = LMean * Lc
5. Pass all solutions where LM < Lth to next iteration, and modify all the other solutions
6. Repeat steps 2 to 5 for all Nr rounds
7. At the end of the Nrth round, select the solution with minimum value of LM (Smin)
8. Select a random MAC implementation from TDMA, BMA or SMAC for transmission of data on the path selected by Smin
9. Store this information in a table for learning

Figure 2: Machine Learning & AI based Mac Optimization Algorithm

For a new communication between the nodes, refer the table and select the MAC protocol which gives minimal value of LM, thereby optimizing the distance of communication, the energy of communication and the link quality for communication. These 3 parameters combined affect the output QoS of the system, and optimize the end to end delay, jitter in delay, the packet delivery ratio (PDR) and communication throughput. We tested our algorithm on various simulation conditions and found it to give optimum results in most of the cases. The results and comparative analysis is described in the next section.

4. Results and Analysis

We tested our machine learning and AI based protocol for various combinations of network states. These combinations include changing the number of nodes, varying the node locations and using standard energy models. The network parameters used are defined as follows:

Table 1
Simulation Parameters

Parameter	Value
Routing algorithm	AODV
Number of nodes	30 to 100
Network type	MANET
Queue	Priority drop tail
Network size	300 m x 300 m
MAC Type	802.11
No. of communications	1-10

A sample machine learning table obtained from our simulations with 20 solutions and 10 iterations is shown as follows:

Table 2
Machine learning Table

Solution	LM	MAC	Iteration
1	2.287	TDMA	6
2	2.39	TDMA	2
3	2.79	SMAC	4
4	2.19	BMA	1
5	2.26	BMA	9
6	2.37	SMAC	4
7	2.41	BMA	2
8	2.15	BMA	7

International Journal of Scientific & Engineering Research, Volume 9, Issue 5, May-2018
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9	2.01	BMA	4
10	2.16	TDMA	3
11	2.23	SMAC	8
12	2.29	TDMA	10
13	2.53	BMA	1
14	2.74	SMAC	6
15	2.79	SMAC	8
16	2.68	TDMA	10
17	2.44	TDMA	7
18	2.62	BMA	4
19	2.91	SMAC	8
20	2.89	SMAC	6

From the above table, we select the 9th solution, which has the minimum LM value obtained at the 4th iterations, and use BMA for communication with the obtained parameter values. In our simulations, we varied the number of solutions from 10 to 200, and the number of iterations from 20 to 500, and observed that the optimum solution for 100 nodes is obtained around 55 solutions and 235 iteration rounds. Any number of solutions and iterations more than that, does not give any significant improvement in the network performance of the system.

In our analysis, we compared the end to end delay for communication, the energy needed for communication, communication throughput, packet delivery ratio and the communication delay, jitter of the proposed protocol with TDMA, BMA and SMAC protocols. The following tables were obtained for 30 nodes and 40 nodes,

Table 3
Energy Consumption for 30 Nodes

Sr. No	No of Communi cations	Energy Consumption in TDMA(mJ)	Energy Consumption in BMA(mJ)	Energy Consumption in SMAC(mJ)	Energy Consumption in AI(mJ)
1	1	15.627	6.759	6.817	0.874
2	2	34.04	17.856	15.946	2.11
3	3	83.034	32.568	36.962	3.097
4	4	127.164	44.648	37.213	3.255
5	5	203.222	62.588	47.244	4.146
6	6	315.004	88.113	68.297	5.687
7	7	452.252	92.667	85.516	8.027
8	8	647.486	105.22	90.809	8.184
9	9	823.192	119.262	101.829	10.942
10	10	1094.701	156.971	123.404	12.492

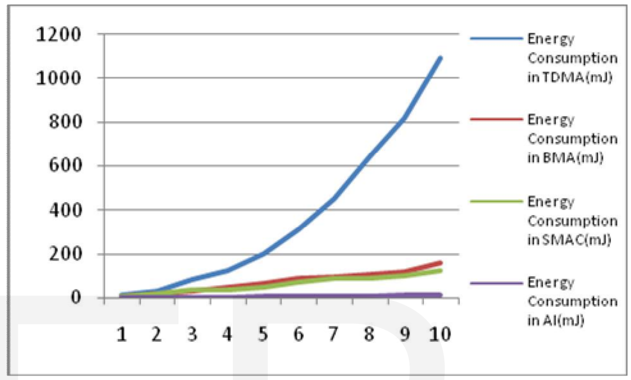

Figure 3(a): No. of communication Vs. Energy Consumption for 30 nodes

Table 4
Energy Consumption for 40 Nodes

Sr. No	No of Communi cations	Energy Consumption in TDMA(mJ)	Energy Consumption in BMA(mJ)	Energy Consumption in SMAC(mJ)	Energy Consumption in AI(mJ)
1	1	11.699	7.906	6.069	0.436
2	2	36.14	13.304	9.594	1.477
3	3	53.147	19.915	17.278	1.868
4	4	110.154	25.614	24.285	2.058
5	5	148.701	41.383	33.362	3.736
6	6	238.869	52.754	39.856	3.918
7	7	356.629	64.821	51.411	4.447
8	8	460.149	67.955	65.438	5.051
9	9	639.534	90.358	67.513	7.446
10	10	829.07	94.7	72.128	7.695

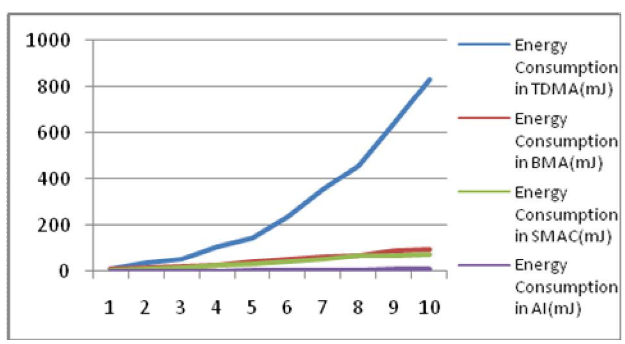

Figure 3(b): No. of communication Vs. Energy Consumption for 40 nodes

International Journal of Scientific & Engineering Research, Volume 9, Issue 5, May-2018
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From the tables and the graphs, it is evident that TDMA consumes the most energy, while our AI based protocol consumes least energy while communicating in the network. Our analysis show that the network lifetime is improved by more than 90% when compared to the TDMA based MAC protocol, and can be seen as follows,

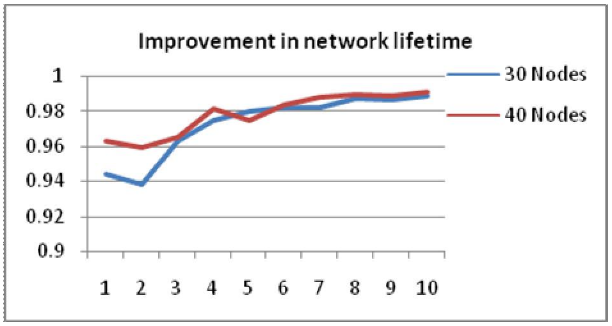

Figure 3(c): Improvement in network lifetime

Similar comparison is made for end to end delay, which can be observed from the following table,

Table 4
Communication Delay for 30 Nodes

Sr. No	No of Communi cations	Delay in TDMA(ms)	Delay in BMA(ms)	Delay in SMAC(ms)	Delay in AI(ms)
1	1	0.000327	0.000192	0.00056	0.0001
2	2	0.000358	0.000402	0.000457	0.0002
3	3	0.000345	0.000236	0.000421	0.000219
4	4	0.000311	0.000264	0.000418	0.000376
5	5	0.000344	0.00028	0.000337	0.000221
6	6	0.000362	0.000311	0.000371	0.000284
7	7	0.000224	0.000283	0.000331	0.000205
8	8	0.00053	0.0003	0.000373	0.000252
9	9	0.00057	0.00031	0.000374	0.000259
10	10	0.00063	0.000308	0.000358	0.00024

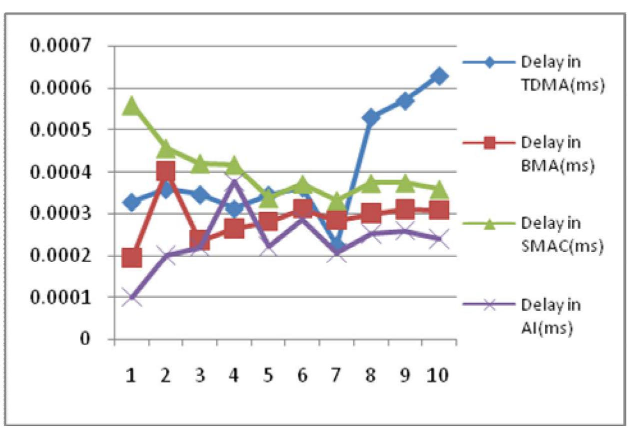

Figure 4(a): No. of communication Vs. Delay for 30 nodes

Table 5
Communication Delay for 40 Nodes

Sr. No	No of Communi cations	Delay in TDMA(ms)	Delay in BMA(ms)	Delay in SMAC(ms)	Delay in AI(ms)
1	1	0.000297	0.000525	0.000316	0.000198
2	2	0.000370	0.000287	0.000278	0.000155
3	3	0.000325	0.000443	0.000425	0.000183
4	4	0.000340	0.000363	0.000320	0.000189
5	5	0.000311	0.000230	0.000320	0.000206
6	6	0.000326	0.000245	0.000303	0.000198
7	7	0.000311	0.000278	0.000342	0.000193
8	8	0.000318	0.000255	0.000326	0.000202
9	9	0.000382	0.000296	0.000351	0.000133
10	10	0.000380	0.000304	0.000318	0.000201

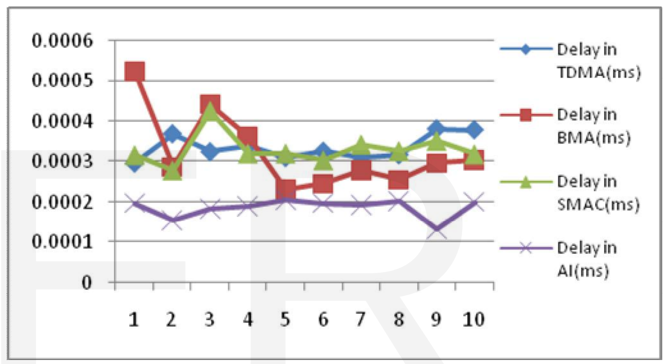

Figure 4(b): No. of communication Vs. Delay for 40 nodes

The end to end delay follows the same trend as the energy consumption, and improves the overall speed of the MAC protocol when AI is used. The speed improvement guarantees faster response of the system, and good throughput when compared with all the other MAC protocols. The comparison graph of delay improvement shows a 30% increase in system speed when compared with the other protocols.

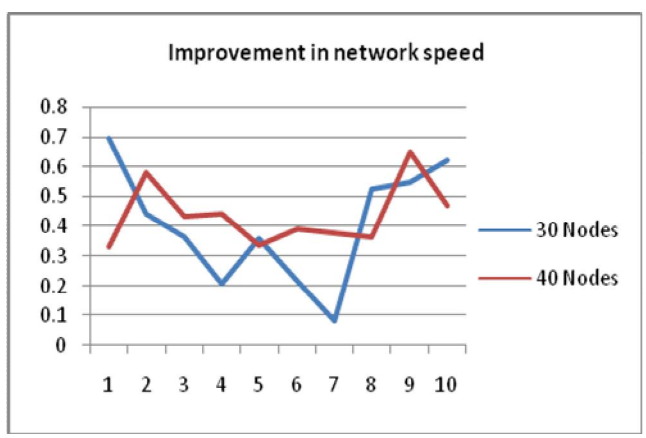

Figure 4(c): Improvement in overall network speed

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The packet delivery ratio (PDR) is also improved when compared to BMA and SMAC, and has similar values when compared to TDMA. TDMA being a low complexity protocol has minimal or no loss in packets, while BMA and SMAC do. Our AI based algorithm overcomes those issues with BMA and SMAC in order to match the PDR similar to TDMA. The results for the same can be observed from the following tables,

Table 6
PDR for 30 nodes

Sr. No	No of Communi cations	PDR in TDMA	PDR in BMA	PDR in SMAC	PDR in AI
1	1	99.878	92.962	97.647	100
2	2	99.807	97.271	96.711	98.937
3	3	99.533	98.196	98.834	97.512
4	4	99.611	98.019	97.596	95.464
5	5	98.284	98.379	97.951	97.728
6	6	99.269	98.988	98.234	98.502
7	7	99.451	98.516	98.152	98.283
8	8	99.57	98.528	98.539	98.711
9	9	99.394	98.861	97.226	98.7
10	10	99.525	98.999	98.99	97.866

Table 6
PDR for 40 nodes

Sr. No	No of Communi cations	PDR in TDMA	PDR in BMA	PDR in SMAC	PDR in AI
1	1	100.0	98.836	97.246	99.208
2	2	99.735	97.813	90.342	100
3	3	99.694	97.918	96.025	98.949
4	4	99.490	97.274	95.874	99.036
5	5	99.300	98.379	97.199	98.847
6	6	99.493	98.398	96.789	99.071
7	7	99.341	98.200	97.820	98.685
8	8	99.226	98.100	97.414	98.758
9	9	99.154	98.487	98.008	97.748
10	10	99.140	98.857	97.726	98.954

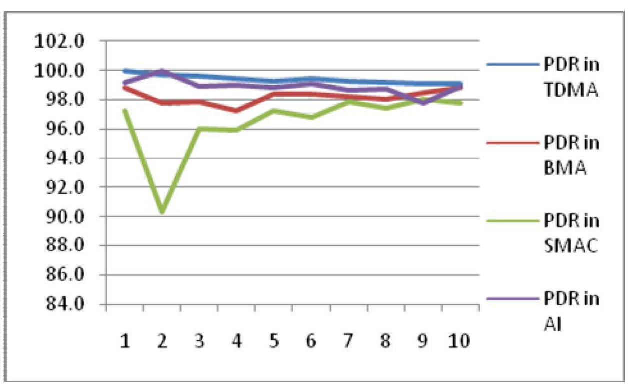

Figure 5: No. of communication Vs. PDR for 30 nodes comparison

The other parameters follow this same trend and tend to improve the overall performance of the system even if the number of communications and other network parameters are varied.

5. Conclusion

The observed results demonstrate that the energy efficiency of the ML-Ai-LL-MAC system is superior to the existing standard MAC protocols like TDMA, BMA and SMAC. The AI layer also improves the speed of communication for the network while maintaining a high packet delivery ratio for any type of network scenario. The system also performs well with varying number of nodes and thus is suitable for any network size. Our observations show that the energy consumption of the network is improved by over 30%, which ensures that the network lifetime will be improved, thus the network can be under operation for more number of communications, this lifetime improvement with improved delay results into faster communications, which allows the network to perform with a better QoS when compared to traditional MAC protocols. This system can be used in real time with practical traffic scenarios in order to improve the overall efficiency of communication in the network.

6. Future work

Our work shows good performance in simulation scenarios, we plan to implement this protocol in real time and check its performance under real life network scenarios. Researchers can test the protocol for other wireless network types like WSNs, MANETs and VANETs in order to check the suitability of the system for their particular application.

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