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ECM-MAC: An Efficient Collision Mitigation Strategy in Contention Based MAC Protocol

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ABSTRACT Medium Access Control (MAC) is the sub-layer of data link layer in the communication OSI model, whose basic function is to control the hardware that interacts with the transmission medium. In Wireless sensor network, the communication is done without any wired connectivity and the sensor nodes get energy through batteries. MAC layer protocol is classified as contention based and contention free. Over the years, these protocols have served efficiently in controlling the data transmission, yet they have some compromising and challenging issues, and data collision is one of them. Contention based protocols are reported to be more vulnerable to collisions, as they allow sharing of channels among transmitting nodes. Collisions result in message delay, data loss and retransmissions, resultantly demanding more energy. Researchers are trying their best to reduce the collisions during transmission. This research is aimed to evaluate the priority-based collision control in contention-based protocol. We present a new technique Energy efficient Collison mitigation MAC (ECM-MAC) protocol to handle the QoS and energy constraints for variety of applications. ECM-MAC uses different contention window and node priority mechanism to get the overall performance of the network. Nodes with most important data or with least residual energy will be allowed to transmit first, thereby minimizing the chances of collisions and maximizing the lifespan of the network. In case of high level of collision, the data traffic will be intelligently reduced to minimize the collisions. A contention-based MAC protocol is evaluated to compare the impacts of suggested mechanism with the standard protocol. It will be useful for designers to develop a better collision avoiding contention-based protocol. In wireless Sensor Networks (WSNs), a sensor node is typically comprising detection unit, transceiver unit (to send and receive the data packets), processing unit and an energy supply unit for energy provisioning. Enhancement in network lifetime is an important and major challenge in WSNs. Since the transceiver unit has more impact on the energy consumption of the node and its reduction results in significant improvement on network lifetime. In our work, we propose an efficient mechanism that prioritized the nodes to get the high performance in quality of service. MAC protocol is targeted to achieve this, as MAC layer has the authority access to the transmission channel. We prioritize the nodes with lower energy to increase the chances of that node to get access of the transmission channel before their power and battery ran out. Our proposed strategy outperforms other protocols in terms of content retrieval Time, retransmissions and energy efficiency.

INDEX TERMS S-MAC, energy efficiency, collision, contention window.

I. INTRODUCTION

Communication for monitoring in the real world has been effectively done through Wireless sensor networks that are a group of small battery-operated nodes. These nodes are usually placed at such places that cannot be reachable easily and have to be controlled remotely. Overall, WSNs are low cost and simple communicating networks as they are free from wired network [1]. WSNs find their applications in a lot of fields such as environmental sensing (temperature, storm, pressure, flood weather forecast, etc.), military tracking, health monitoring (patient monitoring),

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smart homes, traffic control, civil structural health monitoring, and many more.

The OSI model for communication comprises of seven layers, in which the second layer is called Data link layer that is responsible for node-to-node data transfer. It is further divided into two sub-layers as described by IEEE 802 [2]. Medium Access Control (MAC) layer is one of those sub-layers. The main responsibility of MAC layer is to control the hardware that controls transmission of data; thus, it is of high importance. MAC layer protocol is further categorized into two basic types; contention based and contention free. Another type called hybrid has also been devised by combining these two. The contention-based MAC protocols permit more than one user to share the same channel at the same time. For this, some rules are set to provide maximum smoothness of the data flow, such as nodes broadcast their transmission schedules to keep neighbors aware of their transmission times thereby reducing maximum possible chances of collision. But still it has been reported a lot with the issue of collisions. Collisions occur when more than one node tries to address the same destination via the same channel. They may result from overhearing and hidden terminal problem too. Hidden terminal problem means a node (that is not addressed) overhears the RTS (request to send) from the willing to transmit node. This node can then try to respond due to overhearing and as a result collision takes place. Collision results in message delay (latency) and the network may discard messages at the collision area for smooth running of the network. Thus, loss of data is also a major drawback of collisions. Moreover, there may be a need for retransmissions after collisions that result in extra usage of energy and limiting the overall performance of the protocol.

Priority based collision control means selected (most demanded) data will be allowed to be transmitted earlier than the other one. Priority can be set on many aspects, like data type or energy levels of the nodes i.e., transmissions will be allowed for the most important data or for the nodes with lowest residual energy for better performance and increased lifespan of the network. In WSNs, energy conservation is a key research area that in important for the overall QoS of the entire Network. In WSN, maximum of the energy consumes during the transmission process, and that hardware is controlled by the MAC protocols. Improvement in energy efficiency is important that depends upon the improvement in MAC protocol. A huge amount of energy is wasted by the various factors like collision, overhearing, latency and idle listening in traditional MAC protocol and it results in reduced nodal lifetime [3]. Duty cycle selection is essential for energy conservation against periodic sleep/wake of these radio transmission hardware.

A lot of research is going on this aspect, but every solution has its own disadvantages and drawbacks. The main objective of this research work is to develop an algorithm for MAC protocol, in which efficient selection and automatically updating duty cycle according to the traffic load and other features of the network. Main contributions of this research include development of a MAC protocol algorithm which is capable to calculate the traffic load adaptive duty cycle by decreasing the energy consumption, while simultaneously improving or at least maintaining other aspects of QoS such as delay, throughput, packet loss, and collisions etc. The organization of the paper is following.

In section II, we briefly presented the classifications of MAC protocols, section III covers latest literature review. Section IV includes problem statement followed by Section V having proposed solution and algorithms. Section VI describes the simulation details, analysis and results of the proposed scheme along with comparative schemes. Finally, the article is concluded in section VII.

II. CLASIFICATION OF MAC PROTOCOLS

In this section, we discussed about the classification of MAC protocols. Contention based and contention free are the two fundamentals MAC protocols. Hybrid category depicts the features of both of them [4].

A. CONTENTION FREE MAC PROTOCOLS

Among the protocols that are contention free, TRAMA is found suitable for single channeled transmissions, whereas Y-MAC is useful in case of more than one channels. But there is need of international time clock for Y-MAC. To escape from this problem of time clock, DESYNC-TDMA should be considered. But due to equal nodal slots, it has a drawback of bandwidth wasting. And this problem is solved by LEACH with unequal nodal slots by clustering algorithms. Its drawbacks lay in the fact that cluster head remains active all the time and uses more energy. LMAC with distributed algorithm has sufficiently reduced the problem of overhead of physical layer but it has to face the problem of idle listening. There are many further types of MAC protocols in contention free Mac protocols.

B. CONTENTION BASED MAC PROTOCOLS

Among the protocols that are contention based, PAMAS relies on bi-channeled scheme to reduce the collisions but its cost is high. S-MAC relies on the energy conserving scheme of listen-sleep cycles, but comes off with the problems of idle listening and latency due to the fixed cycles. The duty cycles in T-MAC and P-MAC are of adaptive type. But early sleep is the drawback of T-MAC and idle listening is that of P-MAC. Routing Enhanced MAC is useful for communications over single cycle, but face collision problems. For communication in a converge-cast type, Data Gathering MAC is suitable, but only in case of fixed data rate. For varying data rates, bi-channeled Wise-MAC is suitable, but its drawback lies in hidden terminal problem. For collision detection and data recovery, Receiver Initiated MAC effectively detects collisions and can recover the lost data, but its drawback lies in large overhearing costs. There are many further types of MAC protocols in contention free Mac protocols.

C. HYBRID MAC PROTOCOLS

Among the protocols of third type, the hybrid ones, Z-MAC is adaptive for varying traffic loads. Its main drawback is long time required for transmissions. Hybrid MAC Protocols have features combined from contention based and contention free MAC protocols. The Mobility Adaptive MAC overcomes this problem of delay. There is an assumption for this protocol that each node is fully aware of the mobility information, which is not acceptable for large networks.

D. COMPARISON

Improvement in MAC protocol is the most feasible way to improve the battery life and energy efficiency. Idle listening, overhearing, latency and collision are the factors in tradition MAC protocols that reduces the nodal life span to a devastating level due to the wastage of energy. S-MAC protocol derives periodic listen/sleep process and for synchronizing and sleep schedules, it forms virtual clusters. S_MAC protocol uses consumes less energy in low traffic environment and uses in-channel signaling mechanism that makes it adaptive and robust. S-MAC is still not an ideal solution for heavy traffic scenarios. In addition, long listening and idle listening intervals reduce the lifetime of the nodes drastically and making it expensive [5]. QoS of S-MAC protocol needs to be enhanced to increase its energy proficiency by dropping the problem of latency, idle listening, and collisions by applying adaptive duty cycles that varies according to variable traffic load [6].

III. LITERATURE REVIEW

Researchers are working on improvement of MAC protocols to enhance overall QoS and energy consumption. Collision Free Mac protocol (CF-MAC), in [7] modified the collision avoidance and saves a handsome amount of time wasted due to the packet transmission recovery after collision. AS, CF-MAC is delay aware protocol, the researchers claimed the implementation issue of CF-Mac due to the clear lack in channel assessment implementation and integration of the information about number of nodes.

Large number of nodes takes part in the transmission of data at the same time in dense WSN networks that causes serious collision problem. In [8] a channel scheme was used, in which potential collision avoidance mechanism is based on the directional data transmission. A random-access method based on the space time suggested in this scheme. This scheme reduces the frame loss rate and enhances the throughput. Space time-based random-access point is calculated using the optimization techniques. Minimum distance coverage to transmit the data from the sender to the final decision is called directional data transmission.

In [9], a dynamic time slot allocation-based protocol PA-MAC is devised that adapts the priority of the transmission itself. PA-MAC outclassed other protocols in terms of throughput, transmission speed and energy requirements. In this scheme, different priorities have been defined such as emergency data with highest priority, on demand data with the highest priority, but on demand and the periodic data with low priority range. It uses the multiple channels and reduces the collision efficiently.

Collison caused by the hostile nodes is discussed in [10]. Hostile nodes do not follow MAC rules and create noise packets, that results in collision and false data submission. Higher energy loss caused by this situation near to the base station. Authors devised an algorithm to detect the flow rate near the base station and points the corrupt nodes causing collision issues. Better detection of collision initiator nodes has been performed in [10].

In WSNs, low duty cycles are adopted to get higher network lifetime. Small awake periods cause collision at receiver node because of the transmission of same type of data. In cast Collision free data collection (iCore) in [11] proposed, after evaluating the collision issue in many-to-one data collection networks because of duty cycles. The main idea of iCore is to forward the data dynamically without any conflicts by setting the schedule of transmission efficiently. iCore decreases the delay comprehensively. Authors used forwarding sequence optimization and forwarder assignments. A distributed medium access-based control protocol is proposed in [12]. In this research work, collision detection phase with extension of CSMA is devised in large WSNs. A filtration mechanism is used to differentiate the stations with collision and station that survives. Later will select as in next phase of the detection. Collision detection is improved as the mechanism proceeds. To get Maximum through, different optimal number of collision detection phases has been performed. To concurrently achieve the apparently inconsistent goals of low latency and energy efficiency, Convergent MAC (CMAC) is a new low duty cycle Mac protocol presented in [13]. is presented. While supporting low latency, CMAC avoids synchronization overhead. CMAC allows the sensor nodes to process at very low duty cycle by using zero communication in case of no traffic. Anycast method is used to wake up forwarding nodes in case of carrying traffic, and then gradually converges from unsynchronized duty cycling route-suboptimal anycast to synchronized scheduling route-optimal unicast.

In [14], authors focused on the implementation of a logical mechanism for uplink traffic by restricting the nodes from transmission at same time, which extends the CSMA/CA IEEE 802.15.4 by imposing probability of collision and retransmission limit. To evaluate the energy efficiency, data rate and throughput, Markov Chain model is used. Protocol in [14] is energy efficient and suitable for the low data rate network. Large number of retransmissions in high data rate networks results in decreased throughput.

In dense networks, most of the times exponential backoff value is being used for the transmission. In [15] a deterministic backoff value based CSMA/CA protocol is proposed and used after every transmission with acknowledgement (ACK) frame. Standard protocol used at the start of the transmission and after that the working of proposed algorithm come in to play in which every ACK frame holds an extra bit with

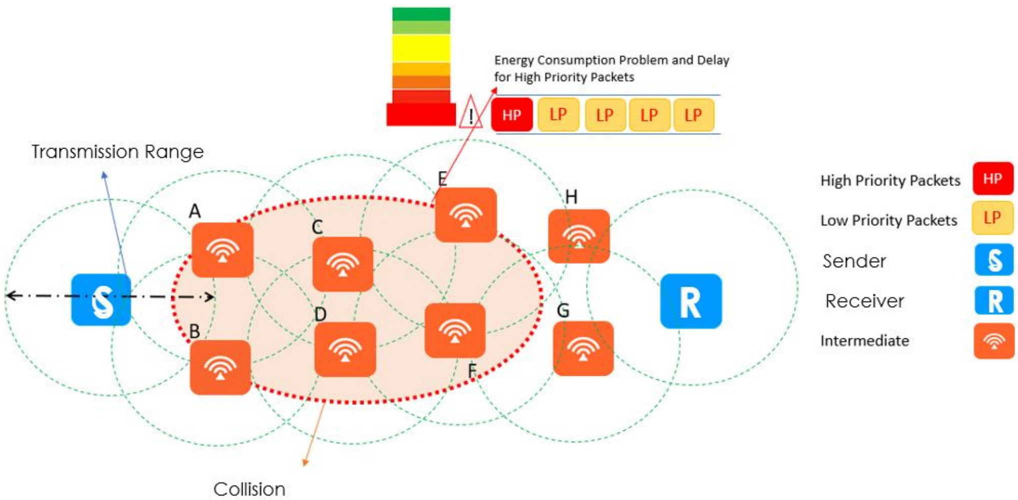

FIGURE 1. Problem scenario for collision and energy consumption in WSNs.

backoff time that indicated the actual slot wait time before next transmission.

To predict the active time of the nodes, an energy efficient MAC protocol with low duty cycle [AP-MAC], is proposed in [16]. In AP-MAC nodes wakeup randomly instead of same time. The randomness in awakening of the nodes is due to the algorithm that decreases the collision and enhances the energy efficiency. The transmission is achieved after the senders' prediction for the wake-up time of the receiver. AP-MAC adapts itself according to the network environment. Duty cycle makes the network scalable at the same time by reducing overall. AP-MAC gives good results in terms of collision avoidance, transmission of data and collision avoidance. A sleep scheduling mechanism with similarity checking is proposed in [17]. Fuzzy matrix is used after the development of the clusters, to check the redundancy of the data. Correlational data nodes are categorized in different categories. After discovery of the similarity, nodes are shifted to sleep mode. This mechanism results in error free, collision free and energy efficient transmission.

Lightweight MAC protocol (LMAC) in [18] is proposed to detect the collision due to the simultaneous data transmission. LMAC results in energy efficiency and collision avoidance using weight increase techniques. Chances of the collision will increase in case of lesser number of time slot as compared to the number of nodes and chances of the network cost will decrease in case of higher number of time slot as compared to the number of nodes. In LMAC, an optimal number of time slots must be chosen to avoid such things. In 2020, an algorithm to reduce the problem of energy consumption, latency and collision in SMAC protocol was proposed by in [19]. The proposed algorithm can vary contention window according to the data traffic and it is capable to handle variable traffic. A technique is used to reduce the collisions, which is helped by contention window. Sensing the carrier is basic mechanism to calculate the traffic and vary contention window. The proposed algorithm was simulated in NS-2 and compared the results with other duty cycled MAC protocols e.g., SMAC. Authors claimed that the proposed algorithm consumed less energy as compared to other MAC protocols and reduced latency as well as collisions. The simulation time is only 10 seconds which is obviously not enough to get more reliable results. There are research works in energy efficiency in [20]–[22]. Recently, Intelligent Transport System in Vehicular Ad Hoc Networks (VANETs) got a lot of attention from the researchers. In [23], authors proposed an analytical model to estimate the effectiveness of EDCAF, used by IEEE 802.11 for VANETs. EDCAF is an enhanced distribution channel access function that is being used by MAC and physical layers in IEEE 802.11 standard that supports the prioritized contention based QoS. Authors also gave consideration to the mobility. A theoretical analysis based on Markov chain model is carried out along with the resultant relationship of EDCAF and performance metrics.

A novel and efficient cooperative MAC protocol (OEC-MAC) based on orthogonal frequency division multiple access (OFDMA), is presented for VANETs in [24] to cop up with problems of collision and packet loss. Access mechanism and channel assignment of subcarrier are provided. The main aim of OEC-MAC is to choose the appropriate transmission mode along with optimal relay. In this scheme Markov chain model is used to provide an analytical analysis. OEC-MAC results in better throughput and strict delay requirement are being followed by the safety messages in VANET scenario. OEC-MAC outperform other schemes in terms of communication reliability and packet drop ratio.

IV. PROBLEM AND MOTIVATION

In contention-based protocols, more than one user can transmit through the same channel simultaneously. This sharing of channels is one of the big culprits responsible for low efficiency of the protocols. Collision is one of the most challenging issues among them. It results in a number of problems hindering smooth signal transmissions such as latency, data and time loss, extra usage of energy and many more.

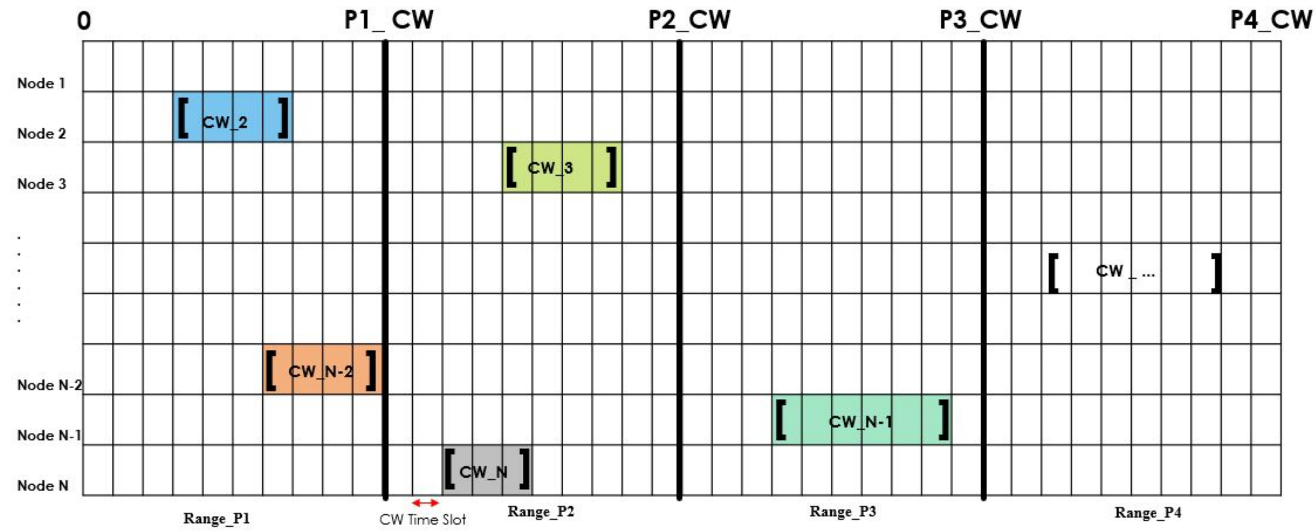

FIGURE 2. ECM-MAC flow diagram.

Latency caused by collisions introduces message delays and wastes a lot of time and energy. Moreover, important data may be lost as a consequence of collision that is again a very big challenge to be solved completely. In addition to this, sometimes nodes try to retransmit the data. In this case, data may be transmitted successfully, but here comes the problem of extra energy usage for retransmissions and a lot of time is wasted, which is crucial for overall efficiency.

In wireless sensor networks, nodes energy is an important and critical factor. Optimization of a node's energy is a hard task in WSNs, since the nodes involves in sensing, processing and other communication tasks. Collison in network cause energy problem in WSNs. Excess in retransmissions due to collision, unnecessary wait for transmission retrieval and excess transmission of periodic and unimportant data through low powered nodes can cause serios network issues. The energy consumption in WSNs largely depends upon the communication protocols. Random and unnecessary awake time period can also cause collision and energy issues. Periodic transmission through low power sensor nodes can cause serious problem for overall network lifetime, data loss and delay issues [22].

This work is focused on studying the performance of a contention-based MAC protocol by avoiding and reducing collisions. The main focus is to study the effects of priority-based collision control technique and altering the data rates in accordance with the collision probabilities, thereby decreasing the chances of collisions and increasing the overall efficiency of the protocol.

The objective of this study is to apply data rate modifications and evaluating its effect on collision probabilities in contention-based protocol and to assess the collision and overall efficiency of MAC protocol after applying priority-based collision control technique on contention-based protocol.

This study will be useful in reducing the collision probabilities and making the MAC protocol energy efficient. It also will be useful in reducing the issue of message delays due to collisions, transmitting at a faster rate and overall QoS of the protocol will be increased. This study is significant in the sense that it is mainly focused on reducing the collision probability in the MAC protocols that are contention based as they are reported a lot to suffer from the collision issue. Moreover, priority technique is applied in three different ways. Thus, it will be very useful for further research.

A. RESEARCH QUESTION

1) What is the effect of data rate modifications on collision probabilities in Contention based protocol?
2) How much is the priority-based collision control technique effective in reducing the collisions, energy consumption and increasing overall efficiency of Contention based protocol.

V. ENERGY EFFICIENT COLLISION MITIGATION MAC PROTOCOL (ECM-MAC)

S-MAC Protocol is considered as the reference protocol in WSNs for MAC layer. Our proposed mechanism ECM-MAC is also based on S-MAC. The simple and effective duty cycle of S-MAC protocol to reduce the idle listening overhead is its main feature. S-MAC alternates two radio modes; active mode and sleep mode. In active mode when nodes are awake, nodes can receive or send data. In case of sleep mode, nodes cannot communicate with the neighbor nodes and turn off their transceivers. Through this mode, nodes can conserve more energy. There is a synchronization method defined by S-MAC that helps to avoid the deaf listening during sleep mode. SYNC packets broadcast periodically by the network nodes at the beginning with a time stamp, in order to synchronize them with each other's.

Clear to Send and Request to Send (CTS and RTS) mechanism are being used by the S-MAC to resolve the hidden station problem. S-MAC framework consist of two phases in active period SYNC phase and DATA phase. In first phase

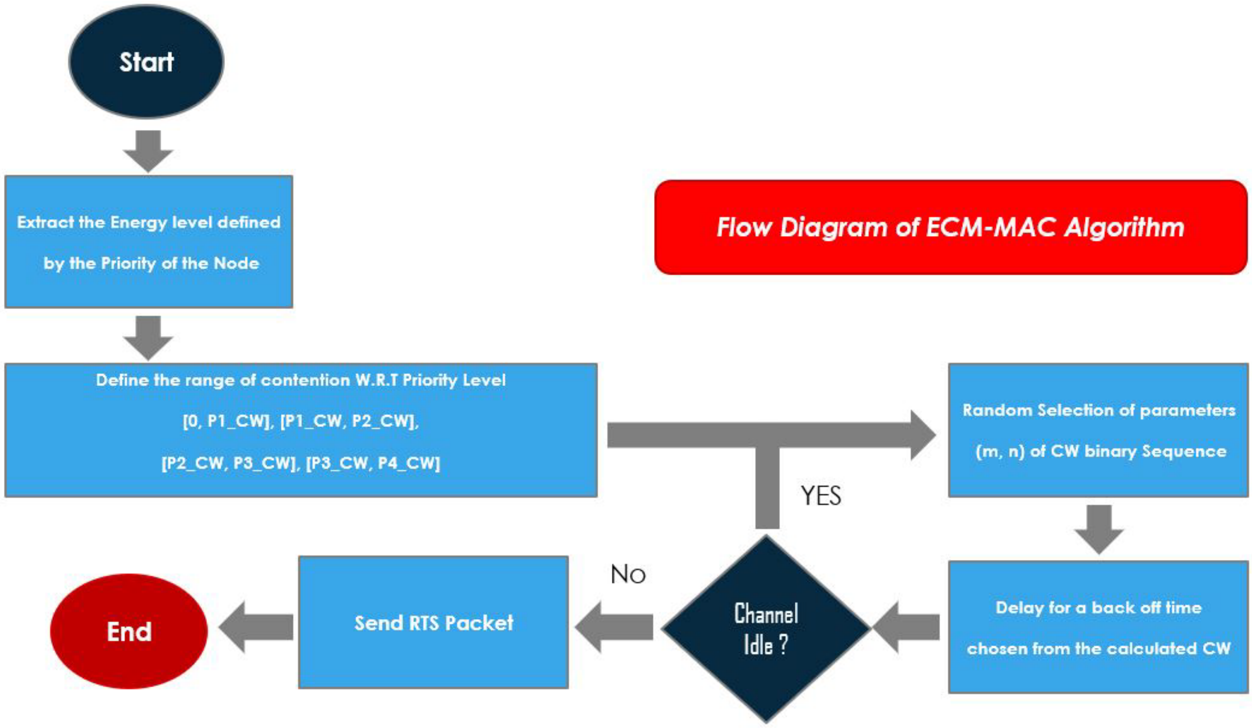

FIGURE 3. ECM-MAC contention window model for priority assignment.

(SYNC Phase), each node periodically broadcasts its schedules and in the second phase (DATA phase), nodes enable their receiving and sending mode. Network nodes waits for a backoff time before sending the RTS message. The interval of the backoff time is randomly chosen and in range of [0, DATA_CW]. There is no priority indication in S-MAC during contention period. To overcome the challenges of S-MAC, we proposed an efficient mechanism ECM-MAC to make network communication efficient and feasible as well as QoS aware. In our work, we proposed an energy efficient collision avoidance mechanism for MAC layer by prioritizing the nodes having lower battery level and lower energy level to take part in transmission process. In our work, we provided a mechanism to avoid the packet collision issue, because of the random backoff time in which potential nodes wait before receiving or sending the data. EMC-MAC mechanism differentiates medium access with respect to the energy level of the nodes to provide the high Quality of Service (QoS) in terms of PDR and consumption of energy.

Initially, a backoff timer is chosen by each of the nodes against each control frame. Backoff timer is chosen randomly in the interval of contention window [0, CW]. At start, the size of CW is set to Minimum contention window size i.e., *CW - CWmin-1*. The contention window size is being adjusted adaptively in range of *[CWmin, CWmax]*. Here, we modify the value of *CWmin* and *CWmax* to change the contention window size. Binary exponential backoff mechanism is adopted in which we need only to change the value of initial CW size *CWmin* to limit the transmission duration accordingly. Minimum Contention window size is (CWmin= 8, 16) here. Lower contention window size is set for the devices with short communication duration and packets with less delay. In case of idle channel for distributed interframe space (DIFS), the timer is decremented and when it reaches to zero, an RTS is send towards the destination from the source node. The neighbor nodes of sender also listen the RTS. The node waits for DIFS = backoff time to retransmit the packet if the channel is idle.

If a node did not received CTS in response from the receiver due to the collision, the size of contention window gets doubles i.e., *CW=2*CWmin* and node then participate in contention process. Conversely, Source node keeps the current value of CW for the successful transmission of RTS after choosing new timer upon new message arrival. The use of RTS/CTS frames result in decreased overhead of control messages as every neighbor of the node is being asked by it to acknowledge the availability of the data. The approach of time slotting makes the access of channel better, especially in data phase that increase the goodput of network. Control messages in our scheme provide decreased contention and more transmission opportunities by assigning random time to the packet of each sender. The combination of time slotting and priority assignment of the node after discovering most suitable node make our proposed design standout in term of accomplishing higher capacity gains as compared to other MAC protocols.

On arrival of each packet, the idea of random backoff time assignment reduces the collision ratio that affects the throughput of system. The random time merely add any delay of transmission of packet because of its small length.

The nodes with lower energy level get the priority and send the data packets in first attempt after utilizing the transmission channel. In other case, if more than one node with same energy level sends the data at same time, then collision will occur and effect out network in negative manners. To deal with this issue, ECM-MAC nodes will pick their backoff time with random ranges. To achieve the priority differentiation to get access of the transmission channel, there are four levels of priority defined. In first level, if the nodes energy is 0%-25, then we need to get the access of transmission channel as quick as possible to use the channel and operate DATA phase. Second and third priority level ranges 25%-50% and 50%-75% respectively. The last and less energy constrained level of energy is 75%-100%. ECM-MAC operated in two different steps.

In first step, based on their battery level, nodes define their priority level and then choose the contention window (CW) to get the backoff time depending on this latter. In our work, we define different ranges of priority to nodes, prioritized based on low energy level and differentiate the priority of medium access. The range of high prioritized nodes is [0, P1_CW]. The range of the nodes with medium priority and the range of the nodes with low priority are [P1_CW, P2_CW] and [P2_CW, P3_CW] respectively. Second step of our fork focuses on the collision mitigation. To get the access of transmission channel, nodes are allowed to randomly pick the *mini_CW_interval* that results in their backoff time. Backoff time gives permission to the nodes of transmission channel access for transmission process. Fig. 2 and Fig. 3 explain the ECM-MAC working in depth. The way nodes get the access of transmission channel and random backoff time is shown in Figure 2. Node N and N1 picked the CW interval from the range of highest priorities (Range_P1= [0, P1_CW]), because both the Nodes N-2 and Node 2 having highest priority level. Node N-2 and Node 2 define their backoff time after selecting the CW and CW1 mini-intervals randomly. Node N and Node 3 having priority of level 2. Period of one time slot is defined as Time Slot Period (TSP). CW defined as the binary sequence of Pi for i nodes, by the ECM-MAC. N is the length of the Pi and the dependance of N lies i how many time slots used by the range of each priority. Repetition of the numbers 0, 1 and 0 points to m, n and k features, respectively. Definition of different states is defined as.

At state 0, nodes are not authorized and cannot get the backoff time before transmission process using this time slot.

At state 1, nodes are authorized and cannot get the back off time before transmission process using this time slot.

We need to give the nodes enough space to choose the bit 1 string, that is why we can choose feature m between [0, n/2]. Computation of feature n can be computed between [, n/m]. We can compute the feature k using n + m + k=N. So, each one node's CW is delimited by [0m] and specified by the bit 1 sequence; CWi = [1n].

VI. SIMULATION AND RESULTS

In this section, different simulation parameters and simulation matrices are used to evaluate the performance of our proposed protocol ECM-MAC. We compared ECM-MAC with native S-MAC and P-MAC protocols. We discussed the results graphs to show the clear difference the performance of our protocol. Previous work for MAC protocol is mostly implemented in Network Simulator 2 (NS-2). In our proposed mechanism, we modified the settings in NS-3 for ECM-MAC. In our simulation environment, we used the IEEE 802.15.4 standards for MAC protocol. We used variation in number od =f nodes i.e., 20, 40, 60, 80 and 100. Transmission range of each node is 100m. The Network range in our simulation is 1000-meter square. We use the topology density over different number of sender/receiver pairs to increase the traffic. The sender and receiver pairs are 1, 2, 3, 4, and 5.

We used NS-3 energy model for the nodes energy and installed the energy model at every node during our simulation. Total simulation time is 1000 seconds, but we evaluate it in different simulation times from 200, 400, 600, 800 and 1000 for more clear results. The initial energy of the nodes is 50J. We evaluate our scheme and comparative schemes over 10 independent runs. The simulation parameters are described in Table 1. Four different performance metrices are used to evaluate the results of ECM-MAC, MDA-SMAC and S-MAC.

1) Total Number of Retransmissions (RTx): It defines the total number of unsuccessful data packets, retransmitted again by the sender nodes due to any network issue.
2) Content Retrieval Time (CRT): It defines the total average time from the initiation of the data packet till the completion of transmission process.
3) Average Energy Consumption: It defines the average energy of all the nodes consumed during transmission process.
4) Network Lifetime (NLT): It defines the time when first node in network dies.

We evaluated all the scheme against total number of nodes, simulation time and number of sender receiver pairs.

In Fig. 4, we evaluate the performance of ECM-MAC against S-MAC and MDA-SMAC by using the performance matrix of the Total Number of Retransmissions (RTx). The value of X-Axis is total No. of nodes and the value of Y-Axis is RTx. The graph illustrates that the ECM-MAC performs better W.R.T RTx. Total number of nodes here are 20, 40, 60, 80 and 100 to experience different density of traffic and packets. In ECM-MAC the use of priority aware mac strategy and contention window slots, the transmission of unimportant packets and use of low power nodes takes place in efficient way. It reduces the collision and retransmissions in the network. In MDA-SMAC initial packet overhead is not discussed and packet priority is not discussed that creates

TABLE 1. Simulation parameters.

Parameter	Value
Communication Channel	Wireless type Channel
Network Range	1000m * 1000m
Radio Propagation Model	Two Ray Ground
Physical Layer	Wireless Physical Layer
Medium Access Control	SMAC
Queue Management	Drop Tail / Priority Queue
Energy threshold	0-25%, 25-50%, 50-75%, 75-100%
Simulation Time	1000 sec
CWmin	8-16
Simulation Time Variation	200, 400, 600, 800, 1000 sec
Number of nodes	20, 40, 60, 80, 100
Technology	IEEE 802.15.4
Number of Sender/Receiver pairs	1, 2, 3, 4, 5
	50
Nodes' Initial Energy	50J
Energy Consumption to Receive	0.3682 J
Energy Consumption to Transmit	0.3862 J
Energy Consumption in Idle State	0.3442 J
Energy Consumption in Sleep State	5.00E-05 J
Network Simulator	NS-3
Application	CBR
Simulation Run	15

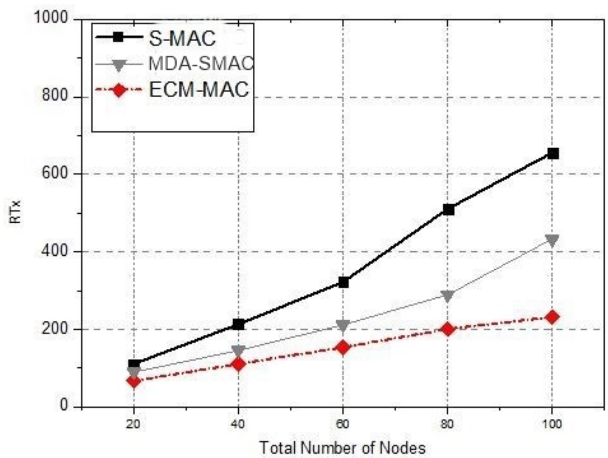

FIGURE 4. Total number of retransmissions against total number of nodes.

excess number of retransmissions due to collision. The trends of the graph show that ECM-MAC outperforms S-MAC and MDA-SMAC. Retransmission is higher with higher number of nodes and vice versa.

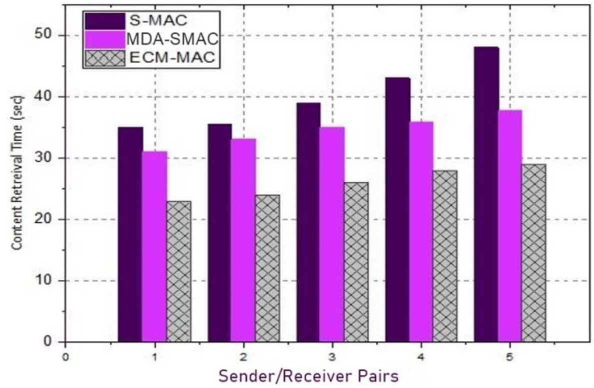

FIGURE 5. Content retrieval time against sender/receiver pairs.

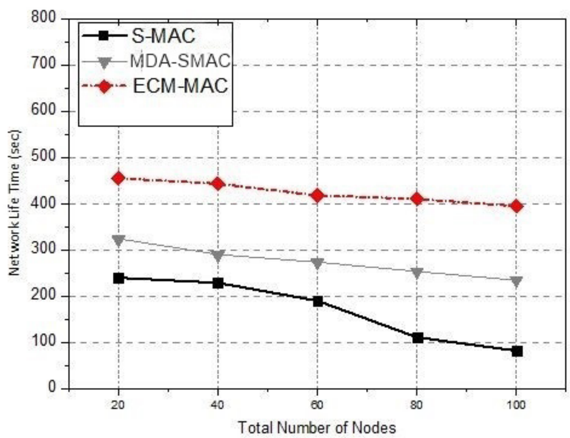

FIGURE 6. Total energy consumption against simulation time.

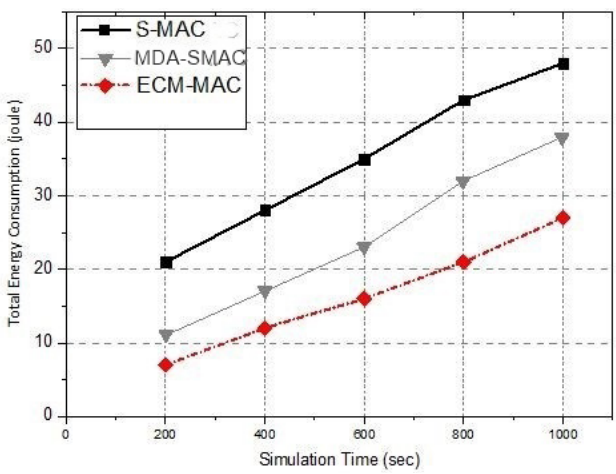

FIGURE 7. Network life time against total number of nodes.

In Fig. 5, we evaluated the performance of all the Mac protocol by taking number of sender and receiver on X-Axis and Content retrieval Time (CRT) on Y-Axis. The performance graph illustrates that ECM-MAC gives the best results in terms of CRT. As we discussed in above graph that the ECM-MAC controlled the retransmissions in the network that reduces the collision and brings energy efficiency. So, The network openness and fluent network transmission results in better CRT. The trends of the bar graph show that with lesser sender and receiver pairs the CRT is on higher side and with more sender and receiver pairs, the CRT is on lower side.

In Fig. 6, we evaluate the energy consumption the nodes against simulation time i.e., 200 sec, 400 sec, 600 sec, 800 sec and 1000 sec. ECM-MAC performs better in this scenario as well. Reduce retransmissions rate and efficient CRT is directly proportional to the performance of ECM-MAC in terms of energy efficiency. Priority mechanism of ECM-MAC efficiently deals with the energy efficiency. This graph depicts that with less simulation time, all the schemes including S-MAC, MDA-SMAC and our proposed ECM-MAC consume less energy and gradually, with increased simulation time, there is an increase in energy consumption as well.

In Fig. 7, we evaluate the performance of ECM-MAC using performance matrix of Network Life Time (NLT). The value of X-Axis is total No. of nodes and the value of Y-Axis is NLT. Total number of nodes here are 20, 40, 60, 80 and 100 to experience different density of traffic and packets. If we want to experience better performance, then NLT should be less. NLT has a direct relationship with energy performance. The more the network is energy efficient and consumes less energy, the more the NLT is. ECM-MAC outperforms the other comparative schemes, S-MAC and MDA-SMAC in terms of NLT. ECM-MAC due to its energy efficient algorithm, in which only restricted nodes can transmit the packet on priority basis performed extraordinary here.

VII. CONCLUSION

This study is aimed to evaluate the priority-based collision control in contention-based protocol. Nodes with most important data or with least residual energy will be allowed to transmit first, thereby minimizing the chances of collisions and maximizing the lifespan of the network. In case of high collision level, the data traffic will be intelligently reduced to minimize collisions. In this article, an Efficient Collision Avoidance Mechanism (ECM-MAC) has been proposed for seamless transmission of packets based upon priority level of the nodes. ECM-MAC aims at reducing the energy consumption and collision by efficient access of the medium using different contention windows. Our simulation results show that ECM-MAC protocol outperform MDA-SMAC and S-MAC protocols in terms of number of packets, Network Lifetime, RTx, Total Energy Consumption and Content retrieval Time.

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