ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

# PC-MAC: PRIORITY CONSTRAINED AND CONGESTION AWARE MAC PROTOCOL FOR MULTICASTING IN WIRELESS BODY SENSOR NETWORKS

**V.T. VENKATESWARLU**[1] **Dr. P.V. NAGANJANEYULU**[2] **Dr. D.N.RAO**[3]
[1]Associate Professor, Dept., of ECE, VVIT Guntur, Andhra Pradesh 522508
[2]Professor and Principal, Dept., of ECE MVRCET Vijayawada, Andhra Pradesh
[3]Professor and Principal
Email: [1]venki.vt@gmail.com, [2]pvnaganjaneyulu@gmail.com, [3]hrowrowv@gmail.com

**ABSTRACT**

MAC (Medium Access Control) protocol is a critical objective in the BSN (Body Sensor Networks).Achieving Quality of Service in Mac protocols towards heterogeneous data transmissions generated from varied sensors is significant research objective. In particular, the efficacy of MAC protocol performance, focusing on the congestion avoidance in multicasting is very essential. Predominantly, the physiological data monitoring applications always generate varied types of traffic comprising multimedia data packets and it is very important to ensure that the heterogeneous traffic schedule of such traffic types are classified based on the priorities and for transmission of the data packets. Considering the pros and cons of various MAC protocol solutions for multicasting that proposed earlier, in this paper, the emphasis is on a novel model of MAC protocol called Priority constrained and CongestionAware MAC Protocol (PC-MAC) for multicasting, in which, the medium access control designed based on traffic prioritization. The structure of data transmission redefined to ensure that the critical data packets transmitted without congestion. PC-MAC protocol shall deliver the missing frames to the multiple sinks with reduced delay that retains the sequence of frames that delivered. The effectiveness of PC-MAC protocol evaluated using experimental studies of simulation carried out in mannasim that build over NS-2. Simulation results have depicted that the proposed model certainly outperforms other contemporary models for BSNs.

**Keywords:** *Medium access control, Wireless Body Area Networks, Wireless Sensor Networks, Energy-Efficiency, Multicast routing, Priority scheduling, congestion avoidance*

## 1. INTRODUCTION

Wireless sensor networks are widely used in applications ranging from healthcare to industrial monitoring. In a complex operating environment, the WSN plays a vital role in augmenting operating support systems [1]. To fulfill WSN capacity, QoS (quality of service) requirements must be enhanced to bring about tangible results. By its very nature, QoS is difficult to achieve owing to the nature of resource constrain of the sensor nodes, fragile wireless links, and rugged operating environments. QoS based media access control (MAC) protocols can be fine-tuned to achieve great energy efficiency, and enhancing QoS parameters, such as reducing the duty cycle of the sensor devices, yielding greater output. Classifying data packets according to their type and differentiating these according to their requirements is becoming a normal trend, instead of providing deterministic QoS guarantees.

The number of applications of WSNs is increasing daily, especially those combining automated sensing, embedded computing, and wireless networking into tiny embedded devices. WSNs are widely used in agriculture and environmental monitoring, and have now been deployed in healthcare, industrial automation, and so on. This shift in trend is due to the proliferation of low cost hardware, micro cameras, and microphones. All these devices have paved the way for WSN applications in non-traditional areas. In these newer application areas, performance and QoS are considered to be crucial [2].

Body Sensor Network (BSN) has revolutionized the way medical monitoring systems are taking shape that has grabbed the interest of many researchers [3] [4]. With the emergence of BSN solutions, the wearable and implantable sensors have become affordable and have become integral part of medical monitoring solutions. Among the key advantages that are extended by BSN, the scope of mobility and the option of implanting the low power implantable or wearable sensor devices in a single body [1] [5] are some of the intrinsic benefits. The level of mobility that supported by the BSNs enables the environment, wherein the patients need not be at hospital for regular monitoring. [6]. in a typical BSN, there are certain low power implantable devices and easily monitored using a smartphone device too.

In the absence of a proper definition of QoS in WSN, it has been widely noted that QoS provides varying ability to users based on their priority, applications, and data flows. However, guaranteeing a certain QoS is challenging owing to the unstable nature of wireless links and network topologies. Moreover, in contemporary applications like health monitoring through body sensors, QoS support is inevitable and the main challenge in this field is energy efficiency [7].

QoS challenges in BSNs differ from those in traditional wireless networks. The challenges faced in WSNs are typically related to resource constraints, node deployment, topology changes, data redundancy, multiple traffic types, real-time traffic, unbalanced traffic, and scalability, whereas QoS challenges are bounded delay, guaranteed throughput, duty cycles, and contention window size. Some QoS aware protocols have been developed for event driven applications based on assigning varying priorities like static priority, dynamic priority, and hybrid priority [7].

Health monitoring environment envisage challenges of different kind of delays and reliability constraints in an application specific context [8] for transmission of data packets from System to the control unit. For instance in the case of ECG (Electro Cardiogram) the data has to be transmitted with very minimal delay and with high reliability levels, and also to ensure that the body temperature measurements has no kind of delay or reliability constraints. In the other dimension, it is very essential that the system have to treat differently than the crucial physiological data packets. The crux of the factor is about developing a protocol, which takes various QoS requirements in consideration, applies data delivery protocols, and ensures suitable application of data delivery protocol.

MAC protocol plays a vital role in the transmission of data packets and the energy consumption pattern [9] and it is very essential to focus on improving the performance of QoS aware MAC protocol for BSN.

There are many studies that were carried out on QoS requirements [10] [11] that have focused on improving the vatious factors such as congestion avoidance, energy efficiency of BSNs. IEE 802.15.4 [12] has the basic idea of defining a frame structure for meeting the varied range of QoS requirements. However, the constraints of rame not being elastic have resulted in a facet, where the protocol does not have priority for missing frames. Body QoS [13] has proposed that addresses the problems of GTS by focusing on the QoS scheduler in the underlying MAC protocol, but the issue of preemption not addressed in the process, thus resulting in lack of transmission slots for the missing data frames, due to the presence of many new frames in the sequence.

PNP-MAC [14] has proposed the concept of preemption and the model focus on giving importance to high priority data packets those transmitted before transmitting the lower priority ones. But one of the key limitation is that there could be more accumulation of low priority data packets. In [15], PLA-MAC (Priority and Traffic Load Aware-MAC) protocol has been introduced in which a new traffic class is introduced, thus focusing on differentiating among the QoS constraints for diverse range of traffic. The PLA-MAC has optimized the ETS (Energy Time Slots) by considering the traffic elements too. However, the pre-assigned ETS might be resourceful or non-resourceful depending on the emerging traffic conditions, and hence the scope for wastage of resources is high. In addition, the other challenge that envisaged in the model is that instantaneous delivery may not be feasible even for the missing frames.

Considering such limitations, MCMAC [16] protocol with enhanced structure to support super-frame is defined, which allows preemption of earlier defined slots for urgent data packets. Such preemptive data transfer carried out using a scheme of polling based decision, which needs control information exchange for each of the slot. Eventually such sturdy communication overhead shall result in overhead and wastage of bandwidth of resources.

Taking such limitations of the existing models in to account, in this paper, proposal of low overhead priority constrained and congestion aware MAC protocol for BSN has discussed. The critical objectives of the proposed model are:

i. Handling diverse range of traffic classes more efficiently
ii. The missing packets transmission should achieve with high priority
iii. The group level transmission should enable multicasting, which is usually a sequence transmission in other contemporary models.
iv. Pre-assigned ETSs should not be in use that ensures to deliver missing frames any time during the regular transmission of the frames.
v. The $ACK$ frames should be limited to avoid the transmission complexity, concerning this, the proposed model dispatches $ACK$ frames to acknowledge the successful delivery of missing frames, whereas the existing contemporary models dispatches $ACK$ frames against successful delivery of each frame.
vi. The protocol comprises a resourceful algorithm for averting the transmission of missing frames conditionally in congestion free environment.

The further sections of the manuscript organized such that the section-2 discusses contemporary models that proposed in the recent past. The Section-3 explores the proposed model and the assumptions considered in the study in detail. The section-4 elaboratessimulation study and performance evaluation of the proposal, and the conclusion of the paper depicted in section-5.

## 2. RELATED WORKS

IEEE 802.15.4 indicates the sub-layer specification for a medium access control that targets low-date-rate wireless connectivity and also in addressing the issues of energy consumption. GTS (Guaranteed Time Slots) with delay-guarantee is developed based on the slot allocation in CFP (Contention Free Period) to receive data from the neighboring nodes. BSN coordination provides GTS slots based on the requests from the nodes during the CAP period. The protocols might have limitations that might have adverse impact of features and performance of BSN.

In compliance to IEEE 902.15.4, seven GTSs are allowed which is not sufficient for BSN applications. In addition, the latency in the allocations of slots are also high, which could be a concern for handling significantly important data. But BSN coordinator also focus on GTS in FCFS manner.

In [17] LDTA-MAC focused on addressing the issues discussed as challenges on GTSs. The novelty of the solution is, GTSs are not fixed and the slot allocation is dynamic based on the traffic load encountered. Super-frame is used for data packets transmission to every successful GTS allocation request. However, the issue of not considering the priority of data packets or the back-off value is a key challenge in the process.

In [13], Body QoS with emphasis on interference in data transmission accounts are considered. The protocol separates QoS scheduler from MAC implementation. This protocol critically addresses limitations of GTS numbers and enabling the QoS Scheduler detached from the MAC protocol that works independently, but in the lower priority data packets could lead to blockage of high priority data packets due to non-preemptive slot allocation. Also, the polling scheme creates additional overheads and towards capturing the scarce BSN resources.

In [18] the model ATLAS is proposed which comprise MAC protocol which has awareness of the traffic load and the super frame structure varies based on the traffic load anticipated. Also, the protocol acclimates multi-hop network model for curtailing occurrence of energy loss because of long range transmission. The critical contribution of the model is super frame structure, which is dynamic and changes according to the traffic load. The limitations in the solution are that it do not differentiate the packets and back off classes. But four types of adaptive super-frame structure based on traffic load is considered, which could result in high computational load issues.

In [14], PNP-MAC is proposed which adapts the super-frame structure of IEEE 802.15.4 and manages GTS slot allocation addressing diverse range of QoS requirements. The contribution of the proposed solution is ability to classify the traffic in to five classes that categorize usage the non-medical multimedia for managing the emergency data in the instance of CFP. But as the CFPs are usually fixed, there is potential chance of loss in time and energy, and lead to holding of critical data for transmission.

In the instance of IP (Inactive Period) getting generated, it could be lost due to issues of idle listening which is not right for emergency and reliability constraints. Major limitation in the proposed model is that GTS requests alone are received by CAP and if any emergency data is generated in such period, it encounters waiting time. Issues pertaining to poor management of priority and load, factors like ETS turn outs are some of the key factors that impact the efficacy of the solution.

In [15], PLA-MAC is proposed with objective of fixing the CFP problems. The model of idle listening in the inactive instances was proposed. The CAP protocol supports transmission of emergency data and also it estimates the quantum of ETs that rely on history and also the volume of ETSs that were earlier used. The protocol also takes in to account the load factor and works on the priority based on traffic generated volume. However, any kind of preemption may not exist and thus resulting in poor response to delivering emergency packets instantaneously.

PRIMA is a priority-based QoS MAC protocol for networks with a large number of sensors [19]. It defines two components: (1) a clustering algorithm to increase scalability, and (2) a channel access method for multi-hop communication. The second component executes the hybrid MAC, which uses CSMS and TDMA. It also minimizes idle listening by forcing non-data nodes. PRIMA uses the basic functionalities of Q-MAC to define the various traffic types, and it maintains four different traffic priorities; high, medium, normal, and low. This protocol executes carrier sensing using the back-off algorithm; it does not use RTS and CTS, but supports only the back-off algorithm [20].

The IH-mac protocol is a type of hybrid protocol. The main objective of IH-MAC is to achieve greater energy efficiency when a large number of nodes are involved in the network. The assignment of time slots to nodes is referred to as broadcast scheduling and for edges this is called link scheduling, which executes parallel communication [21].

This method results in a MAC protocol that gives priority to a queue with the maximum load, which means that an overloaded node gets the highest priority for the channel avoiding packet delay and dropped packets [22], [23], [24]. An enhanced version of the distributed channel access method has been developed, the performance of which with and without contention-free bursts (CFB) was compared with respect to energy consumption using IEEE 802.11 DCF. This proved that EDCA CFB gives better performance [25].

RL-MAC uses a similar frame structure to S-MAC and T-MAC, but has distinct feature. When compared to the above protocol, its duty cycle is dynamically changed according to the intended traffic load for the node [26]. It proposed the AQ-MAC protocol, Asynchronous MAC for QoS in WSN satisfies the energy efficiency by classifying data into various static priority. Performance is compared with RI (Receiver Initiated)-MAC [27], [28].

AS-MAC (An asynchronous scheduled MAC) inherits the concepts from PW-MAC (predictive–wakeup), it’s used to avoid the collision and re-transmission [29].

RF-MAC (Radio Frequency-MAC) protocol used to recharge the wireless sensor nodes by setting the priority level based on the battery level. A specific battery threshold is set for the sensor nodes in the case power level is less than the threshold value, and that particular sensor node gets charged. The requesting node sends the Radio frequency Energy packet for instant charging [30], [31].

Two Tiered Service Differentiation (TTSDM) and Data Rate Adjustment Scheme (DRAS) is based on CSMA/CA protocol, for security application in battle field. This protocol transmits continuously monitoring the data periodically, if any event is introduced like for e.g. battlefield, it overcomes the regular data monitoring prioritizing critical data that is a real time video traffic. Instead of giving energy efficiency it gives importance to minimizing the latency [32].proposed method is based on open source frame work KS pot energy consumption minimized by node load balance making tree structure, balancing the data transfer load by synchronizing the node [33].

Dyn MAC-(Dynamic MAC) is enhanced from Gin MAC protocol which is developed in GINSENG project based on TDMA. The main function of this

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

protocol is dynamic reconfiguration of the channel which is used for the nodes to recover from the connection loss [34].

In [16], McMAC is proposed which supports data types based on the delay and reliability constraints. Also, it reduces usage of BSN resource according to the variation in the types of transmissions. The issues of starvation resulting from non-delivery of constrained packets and the ordinary packets not delivered due to CFP period are addressed in the solution. In the instances of non-delivered packets traced, BSN coordinates dispatch poling message to sensors prior and post the transmission, and it supports in captivating information pertaining to varied scare resources of BSN.

Also, the other key loophole envisaged is that it classifies the CAP and CFP in to vivid sections. In the absence of type-1 packets, there is certain quantum of pre-defined waiting time, resulting in loss of bandwidth.

It is imperative from the earlier contributions that many researches have focused on improving the energy efficiency of BSNs [35] [36]. In [36], the model proposes the method of wake-up schedule for sensor nodes, which could result in improving the energy-efficiency. However, the issues of accuracy plague the proposed model. The study has introduced secondary transmission channel for passive receiver service and the receivers were proposed for receiving energy from the frequencies established with the coordinator, but such method could lead to implications for human health. Also, the model do not focus on reliability, delay and other such critical QoS constraints that are essential for data generated from the sensor nodes.

The contribution depicted in [16] is considering the objectives similar to the objectives considered by the model contributed in this manuscript. However, the model depicted in [16] is not resourceful for health tracking applications and the model supports data of one or more traffic classes to be unavailable in any instance. In PC-MAC, concatenated CAP and CFP‘s are used for curtailing the waiting time to few data packets, while other packets are not available.

Secondarily, McMAC adopts the FCFS system for allocating the similar kind of packets and it could lead to packet drops because of lifetime expiry of packets due to missing sequence.

On contrary, PC-MAC focuses on sequencing the packets resulting from traffic based on missing frames information. Such method leads to transmit the missing frames first, and reducing the packet drops, leading to increasing the reliability issues. Instead of broadcasting missing frames at every slot for handling emergency traffic, PC-MAChalts the transmission of regular traffic until missing frames delivered successfully. Considering such factors, it can state that PC-MAC reduces the congestion and process overhead whilst maintaining the higher data delivery performance.

## 3. PRIORITY CONSTRAINED CONGESTION AWARE MEDIUM ACCESS CONTROL PROTOCOL (PC-MAC) FOR MULTICAST DATA TRANSMISSION

The proposed model is a designed for Priority Constrained Congestion aware MAC level routing that focuses on reducing the delay in the data delivery and improves the reliability for high priority data. In addition, the act of inducting mini slots for contention free period in proposed model supports the instant transmission of high priority packets, which is important in health monitoring applications. The preemption algorithm that devised in the proposed model provides high priority for urgent packets and addresses the issues of starvation problem, which is a critical, constrained observed in the existing works.

The crux of PC-MAC is about reliability transmission of packets to the neighbor nodes. In the PC-MAC designed based on transmission window structure that influenced by IEEE 802.11 transmission structure, the operational overview of the proposed model is reliant on the following aspects.

### 3.1 IEEE 802.11 Transmission Overview

IEEE 802.11 which is used as a collision avoidance scheme which includes RTS/CTS/ACK kind of control frames that are adapted for transmission of unicast packets. In 802.11, the DCF (Distributed Coordination Function) depicts the basic access method which mobile node is impacting in terms of sharing the wireless channel. Scheme combines CSMA and the acknowledgement of ACK. Mobile nodes depending on their need can focus on virtual carrier sense mechanism that provides RTS/CTS exchange for channel reservation and fragmentation of packets in situation. Receiving RTS, CTS or the data frame is not being real to the destination of any node, but it could impact the data exchange in terms of destination of node. Reception of RTS, CTS or the data frames is not turning out to be the real destination of any node, and the crux is about real destination node. For the broadcast packets, IEEE 802.22 nodes only execute the process of avoiding the collisions and transmit data frame.

### 3.2 PC-MAC Transmission Window Structure

The general scenario of the data multicast transmission between a node and all its hop level target nodes is as follows. Each node $n$ that multicasts the prescribed frames, maintains the list $NHL$ of one hop level neighboring nodes and the list $TF$ of frames already transmitted. Node $n$ utilizes the frames that received to track the target nodes from the list $NHL$. The list $TF$ caches the frames, which already transmitted and the same is critical to retain the frame that requires retransmitting. The list $TF$ eventually refines by pruning the frames those successfully delivered to target nodes. The node $tn$ that exists in the list $NHL$ of the node $n$ also maintains a list $RF$ to retain the sequence id of the frames received, which further transfers toits one-hop neighbors. The node $n$ shares $RTS$ (Request to Send) frame to all its target nodes that carries sequence ids of the frames to be transmit. Then each target node $tn$ verifies the missing sequence ids by comparing the sequence ids found in $RTS$ frame and the sequence ids exists in $RF$, such that any sequence ids between the sequence ids exists in $RTS$ frame and the list $RF$. If missing frames observed, then target node $tn$ informs the same to source node $n$ by transmitting a $CTS$ (clear to send) frame that contains the list of sequence ids of the missing frames.Each target node acknowledges if desired frames delivered successfully. If the node $n$ that sends frames observed any of the frame in corrupted state, then pauses the RTF frame transmission process until it receive the corresponding frame with desired content from the buffer. Upon successful replacement of the corrupted frame, the node $n$ resumes the process and executes the whole process that explored. The overall process of transmission of missing frames usually denotes as $CTS/DATA/ACK$ (Clear-to-Send/ Missing-Frames-Transmission/ Acknowledgment). Each target node utilizes the $CTS$ frame even to alert the source node $n$ about the further frames in sequence of present frames delivered. During this, the node $n$ pauses the further transmission to the target node $tn$ that received all frames successfully, which is until all other target nodes in the list $NHL$ sends acknowledgement about the successful delivery of the all transmitted frames in earlier cycle. Hence, it is evident that the repetitive transmissions due to collision factors and the delay transmissions to the node that does not have any missing frame in transmission cycle.

In order to overcome these limits, the PC-MAC performs channel verification for collision avoidance that termed as Carrier-sense multiple access with collision avoidance (CSMA/CA), which does prior to the transmission of RTS. The rest of the process that transmitting RTS frame to target nodes and using this RTS frame, the respective target node identifies missing frames and sends CTS to source that notifies source node about the missing frames.PC-MAC also focuses on minimizing the process delay to notify the status of the frames sequence that delivered to target nodes. In this regard, PC-MAC relies on a Boolean flag $cf$. The frames that should transmit to target nodes accumulated in to list $RF$ and frames that transmitted to target nodes listed in list $TF$. The flag $cf$ value is true by default, and if flag value is true then respective node initiates the transmission of the $RTS$ frame that carries the information about sequence of frames accumulated in list $RF$. During the $RTS$ frame transmission process, if any new frame joined to $RF$, then flag $cf$ will be set to false, if Boolean flag value is false then corresponding node pauses the next $RTF$ frame transmission process and completes the $RTF$ frame transmission of current cycle and its related missing frame requests if any. Upon completion of the current $RTF$ frame transmission and corresponding missing frame requests, if new frames found in $RF$ then flag $cf$ is set to true else halts the transmission process until flag $cf$ value set to true.

### 3.3 Critical Packet Sequencing By PC-MAC to Avoid Congestion

To address the congestion avoidance, the PC-MAC devised such thatany multicast routing protocol can use PC-MAC as underlying MAC layer. PC-MAC supports in eliminating the congestion by focusing

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

on ordering first sequence to cast the packet for all target nodes in broadcast manner. Following the PC-MAC process explored using illustrative representation.

step 1: Let node $n_1$ multicasts the data frames to one-hop neighbor nodes $\{n_2, n_3, n_4, n_5\}$ denoted as list $HNL(n_1)$ in further discussion.

step 2: The flag $cf(n_i)$ set to true if frames exists in list $RF(n_1)$ of the node $n_1$ that further multicasts to the target nodes in list $HNL(n_1)$.

step 3: Since the flag is set to true, the node $n_1$ initiates to broadcast $RTS$ frame that represents the sequence of ids $\{fid_0, fid_1, fid_2, ..., fid_i\}$ of the frames found in list $RF(n_1)$ concerning the first cycle of the transmission to the target nodes in list $HNL(n_1)$.

step 4: Further, the node $n_1$ broadcasts the frames represented by sequence of ids $\{fid_0, fid_1, fid_2, ..., fid_i\}$ to all target nodes. During this phase, if any of the new frames arrived to node $n_1$, which buffers in to list $RF(n_1)$, the flag $cf(n_1)$ turns to false.

step 5: Upon completion of transmission of frames represented by sequence of ids $\{fid_0, fid_1, fid_2, ..., fid_i\}$, the node $n_i$ buffers the copy of all these frames in to list $TF(n_1)$ and verifies the status of the list $RF(n_1)$ and if new frames found in list $RF(n_i)$ then flag $cf(n_1)$ sets to true. Since the flag $cf$ is set to true, the node $n_i$ initiates next cycle of transmission that broadcasts $RTS$ frame with sequence ids $\{fid_{i+1}, fid_{i+2}, ... fid_{i+j}\}$.

step 6: Further the target nodes those received the $RTS$ frame of the current cycle verifies the missing frames if any, which performs by verifying that the ids of the frames received and ids represented by the current $RTS$ frame are in sequence or not.

step 7: If missing frames identified by any of the target nodes in list $HNL(n_1)$ then respective nodes send $CTS$ frame that represents the missing frame ids to the node $n_i$.

step 8: Upon receiving the $CTS$ frame if any, node $n_1$ sets flag $cf$ value false and abundance the present cycle of transmission of the frames represented by ids $\{fid_{i+1}, fid_{i+2}, ... fid_{i+j}\}$.

step 9: Then initiates the broadcasting of the frames found in list $TF(n_1)$ referred by ids found in respective $CTS$ frames received from one or more target nodes.

step 10: Upon completion of retransmission of the missing frames, the node $n_1$ resets the flag $cf(n_1)$ to true and reinitiate the new transmission cycle that broadcasts the $RTS$ frame, which represents the sequence ids $\{fid_{i+1}, fid_{i+2}, ... fid_{i+j}\}$ of the frames found in list $RF(n_1)$.

step 11: On other dimension of the process, if node $n_1$ does not receive any $CTS$ frame, or it received the $ACK$ frame from one or more target nodes that represents the successful delivery of the all missing frames, then the node $n_1$ discards the copy of the frames those transmitted in earlier cycles from the list $TF(n_1)$.

step 12: In addition, resets the flag $cf(n_1)$ to true, which allows the node $n_1$ to resume the transmission of the frames buffered in list $RF(n_1)$.

This transmission process explored in steps 1 to 12 is cyclic at all nodes those required to multicast the data to all of their one-hop neighbor nodes, which continues until the data transmission ends between the source and all of the target sinks.

## 4. SIMULATIONS AND RESULTS DISCUSSION

The experimental study of the proposed model performed on simulations build using Mannasim [37] framework that build on NS-2 [38], the input parameters of the simulation depicted in table-1. The proposed model PC-MAC compared to a contemporary model called MC-MAC[16]that found in recent literature.During the performance analysis, the contemporary quality of service metrics such as Packet delivery ratio with bounded-time persistence (in time delivery ratio of the packets), end-to-end delay and process overhead assessed for both PC-MAC and MC-MAC and compared.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

*Table1: Simulation Parameters Chosen For Experiments*

| | |
|---|---|
| Number of nodes Range | 10 to 40 |
| Network range | 1100 m × 700 m |
| Payload | 512 bytes/packet |
| Route request timeout threshold | 40 seconds |
| Bandwidth at physical links | 2 Mbps |
| Cache update strategy | Priority First |

The packet delivery ratio observed for both PC-MAC and MC-MAC is above 95% that depicted in figure 1.

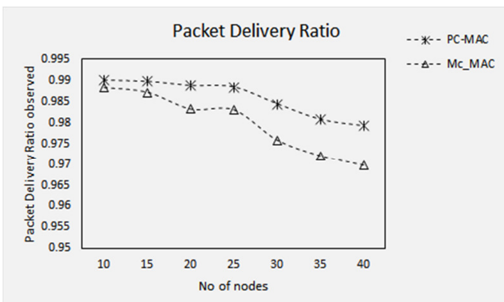


*Figure 1: The Comparison Of Packet Delivery Ratio Observed For MC-MAC And PC-MAC*

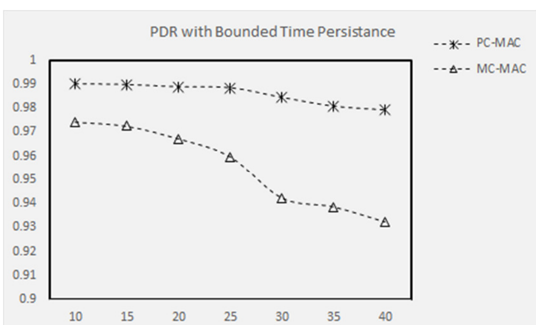


*Figure 2: Comparison Of Packet Delivery Ratio With Bounded Time Persistence Between PC-MAC And MC-MAC*

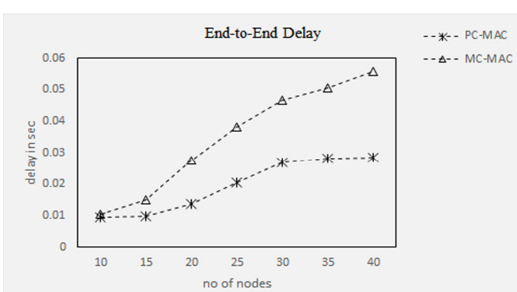


*Figure 3: Comparison Of End-To-End Delay Observed Between PC-Mac And MC-MAC*

However, packet delivery ratio with bounded time persistence is substantially low in MC-MAC that compared to PC-MAC (depicted in figure 2). The bounded time persistence and end-end delay observed for PC-MAC is significantly high and low respectively, which is since successful avoidance of congestion and control packet overhead in PC-MAC that compared to MC-MAC. Hence, the end-end delay also considerably low in PC-MAC (see fig 3).

The process overhead is depicted by the aggregate value of the number of retransmissions occurred for data frames (due to congestion) and the number of control packets involved that depicted in figure 4. The occurrence of retransmission of the data frames is very low in PC-MAC, which is due to the successful priority based multicast strategy proposed in PC-MAC. In addition, the control packets involved in PC-MAC are low, since the $ACK$ frames sent by target nodes only to acknowledge the successful delivery of the missing packets.

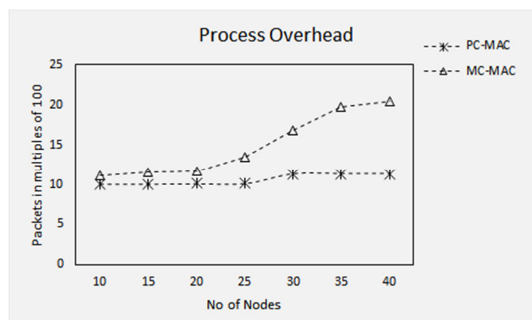


*Figure 4: The Comparison Of Process Overhead Observed For MC-MAC And PC-MAC*

The phenomenal advantage of the PC-MAC that senses from the experimental study is successful avoidance of the congestion during multicasting the data frames at MAC level, which achieves linearity in process complexity. This is since, the retransmission of the frames are conditional and limited to only missing frames and the node that multicasts the sequence of data frames is not flooded with acknowledgements as the target nodes send $ACK$ frames upon receiving missing frames successfully.

## 5. CONCLUSION

This manuscript explored a priority constrained and congestion aware MAC level multicast transmission (PC-MAC) for wireless body area networks. The critical objective of the proposal is congestion avoidance at group level transmission occurs at multicasting routes. Unlike existing contemporary models that transmit data in sequence at group level, the proposed model multicasts at group level with minimal control overhead and congestion avoidance. The PC-MAC can use as underlying mac layer for any contemporary multicasting protocols found in literature. The experiments conducted on simulation environment and performance of the proposed model assessed through metrics like Packet delivery ratio with and without bounded time persistence, process overhead and end-to-end delay. The results obtained concerning these metrics were compare to the other contemporary model called MC-MAC, which evinced the significance of the proposal towards congestion avoidance, bounded time persistence and minimal process overhead. The future research can extend this model to schedule the frames based on their delay sensitivity.

***Conflict of Interest:***

All authors certify that they have participated sufficiently in the work to take public responsibility for the content, including participation in the concept, design, analysis, writing, or revision of the manuscript. Furthermore, each author certifies that this material or similar material has not been and will not be submitted to or published in any other publication

**REFERENCES:**


[1] Milenkovic, A., Otto, C., & Jovanov, E. (2006). Wireless sensor networks for personal health monitoring: issues and an implementation.Computer Communications, 29(13–14), 2521–2533. doi:10.1016/ j.comcom.2006.02.011. (Wireless Sensor Networks and Wired/Wireless Internet Communications).

[2] Martı´nez, J.-F., Garcı´, A.-B., Corredor, I., Lo ´pez, L., Herna´ndez, V., & Dasilva, A. (2007). QoS in wireless sensor networks: Survey and approach. InProceedings of the 2007 Euro American conference on Telematics and information systems(p. 20).

[3] Gopalan, S.A., Energy-efficient MAC protocols for wireless body area networks: Survey, Ultra-Modern Telecommunications and Control Systems and Workshops (ICUMT), 2010.

[4] Latre, B.; Braem, B.; Moerman, I.; Blondia, C., A Survey on Wireless Body Area Networks. Wireless Networks Volume 17 Issue 1, January 2011.

[5] Chris Otto, Aleksandar Milenkovic, Corey Sanders, Emil Jovanov System architecture of a wireless Body area sensor Network for ubiquitous health monitoring, Journal of Mobile Multimedia, vol. 1, no. 4, pp. 307–326, Jan. 2006

[6] Ian F. Akyildiz, W. Su, Y. Sankarasubramaniam, E. Cayirci Wireless sensor networks: a survey. Computer Networks, vol. 38, no. 4, Mar 2002.

[7] Yigitel, M. A., Incel, O. D., & Ersoy, C. (2011). QoS-aware MAC protocols for wireless sensor networks: A survey.Computer Networks, 55(8), 1982–2004.

[8] M.A. Ameen, Ahsanun Nessa, Kyung Sup Kwak, QoS issues with focus on Wireless Body Area Networks. Third 2008 International Conference on Convergence and Hybrid Information Technology

[9] Petcharat Suriyachai, Utz Roedig, and Andrew Scott, A Survey of MAC Protocols for Mission-Critical-Applications in Wireless Sensor Networks, IEEE Communications Surveys and Tutorials, vol. 14, no. 2, pp. 240–264, Mar. 2011.

[10] Dr. Md. Abdur Razzaque QoS Provisioning in Wireless Sensor Network. For Location Aware Network. VDM Verlag.

[11] Hossain, M.S., El Saddik, A., QoS Requirement in the Multimedia Transcoding Service Selection Process., IEEE Transactions on Instrumentation and Measurement, June 2010, vol. 59 , no. 6, pp. 1498–1506 )

[12] Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Low-Rate Wireless Personal Area Networks (WPANs), IEEE Std 802.15.4-2006

[13] Gang Zhou, Jian Lu, Chieh-YihWan, Mark D. Yarvis, and John A. Stankovic BodyQoS: Adaptive and Radio-Agnostic QoS for Body Sensor Networks, INFOCOM 2008. The 27th Conference on Computer Communications, IEEE, April 2008.

[14] Yoon, J.S. , Gahng-Seop Ahn , Seong-Soon Joo , Lee, M.J. PNP-MAC: Preemptive Slot Allocation and Non-Preemptive Transmission for Providing QoS in Body Area Networks, Consumer Communications and Networking Conference (CCNC), 2010 7th IEEE

[15] Iffat Anjum, Nazia Alam, Md. Abdur Razzaque, Mohammad Mehedi Hassan, Atif Alamri A Priority Based Traffic Load Adaptive MAC Protocol for QoS Provisioning in Body Sensor Networks, International Journal of Distributed Sensor Networks, vol. 2013 (2013)
[16] Muhammad Mostafa Monowar, Mohammad Mehedi Hassan, Fuad Bajaber, Musaed Al-Hussein, and Atif Alamri McMAC: Towards a MAC Protocol with Multi-Constrained QoS Provisioning for Diverse Traffic in Wireless Body Area Networks, sensors ISSN 1424-8220, 2012.
[17] Li C, Hao B, Zhang K, Liu Y, Li J. A novel medium access control protocol with low delay and traffic adaptivity for wireless body area networks. Journal of Medical Systems, Springer. October 2011, vol. 35, pp. 1265–1275.
[18] Md. Obaidur Rahman, Choong Seon Hong, Sungwon Lee, and Young-Cheol Bang. ATLAS: A Traffic Load Aware Sensor MAC Design for Collaborative Body Area Sensor Networks. Sensors 2011, pp. 11560–11580
[19] Ben-Othman, J., Mokdad, L., & Yahya, B. (2011). An energy efficient priority-based QoS MAC protocol for wireless sensor networks. In Communications (ICC), 2011 IEEE International Conference on (pp. 1–6).
[20] Zarei, Z., Safavi, S. M., & Abbasi, A. (2012). A MAC protocol for provisioning QoS and energyefficiency in WSNs. International Journal of Computer Theory and Engineering, 4(4), 489–493.
[21] Arifuzzaman, M., Matsumoto, M., & Sato, T. (2013). An intelligent hybrid MAC with traffic-differentiation- based QoS for wireless sensor networks. IEEE Sensors Journal, 13(6), 2391–2399.
[22] Khiati, M., & Djenouri, D. (2012) Cluster-based fast broadcast in duty-cycled wireless sensor networks. In Network Computing and Applications (NCA), 2012 11th IEEE International Symposium on (pp. 249–252).
[23] Lu, J., Van Den Bossche, A., & Campo, E. (2012) Improving robustness and flexibility of MAC layer for guaranteed QoS indoor monitoring in wireless mesh sensor networks. In Wireless Communications in Unusual and Confined Areas (ICWCUCA), 2012 International Conference on (pp. 1–6).
[24] Touil, H., Fakhri, Y., & Benattou, M. (2012). Energy-efficient MAC protocol based on IEEE 802.11e for wireless multimedia sensor networks. In Multimedia Computing and Systems (ICMCS), 2012 International Conference on (pp. 53–58).
[25] Wang, Y., Vuran, M. C., & Goddard, S. (2012). Cross-layer analysis of the end-to-end delay distribution in wireless sensor networks. IEEE/ACM Transactions on Networking, 20(1), 305–318.
[26] Zhao, J., Qiao, C., Sudhaakar, R. S., & Yoon, S. (2013). Improve efficiency and reliability in single-hop WSNs with transmit-only nodes. IEEE Transactions on Parallel and Distributed Systems, 24(3), 520–534.
[27] Nguyen, K., & Ji, Y. (2012). Asynchronous MAC protocol with QoS awareness in wireless sensor networks. In GLOBECOM—IEEE Glob. Telecommun. Conf. (pp. 555–559).
[28] Fafoutis, X., Di Mauro, A., Vithanage, M. D., & Dragoni, N. (2015). Receiver-initiated medium access control protocols for wireless sensor networks. Computer Networks, 76, 55–74.
[29] Jang, B., Lim, J. B., & Sichitiu, M. L. (2013). An asynchronous scheduled MAC protocol for wireless sensor networks. Computer Networks, 57(1), 85–98.
[30] Naderi, M. Y., Nintanavongsa, P., & Chowdhury, K. R. (2014). RF-MAC: A medium access control protocol for re-chargeable sensor networks powered by wireless energy harvesting. IEEE Transactions on Wireless Communications, 13(99), 3926–3937.
[31] Doudou, M., Djenouri, D., Badache, N., & Bouabdallah, A. (2014). Synchronous contention-based MAC protocols for delay-sensitive wireless sensor networks: A review and taxonomy. Journal of Network and Computer Applications, 38, 172–184.
[32] Ozen, Y., Bayilmis, C., Bandirmali, N., & Erturk, I. (2014). Two tiered service differentiation and data rate adjustment scheme for WMSNs cross layer MAC. In Proceedings of 11th International Conference on Electronics, Computer and Computation (pp. 1–4). Abuja, Nigeria.
[33] Andreou, P. G., Zeinalipour-Yazti, D., Samaras, G. S., & Chrysanthis, P. K. (2014). A network-aware framework for energy-efficient data acquisition in wireless sensor networks. Journal of Network and Computer Applications, 46, 227–240.
[34] Correia, L. H., Tran, T. D., Pereira, V. N. S. S., Giacomin, J. C., & Sa´ Silva, J. M. (2015). DynMAC: A resistant MAC protocol to

coexistence in wireless sensor networks. Computer Networks, 76(1), 1–16.

[35] X. Zhang, H. Jiang, X. Cheng, L. Zhang, An energy efficient implementation of on demand MAC protocol in medical Wireless Body Sensor Networks. Circuits and Systems, 2009, ISCAS 2009, IEEE International Symposium, May 2009.

[36] X. Zhang,H. Jiang , L. Zhang, C. Zhang, An Energy-Efficient ASIC for Wireless Body Sensor Networks in Medical Applications. Biomedical Circuits and Systems, IEEE Transactions, vol. 4, no. 1, Feb. 2010.

[37] Pereira, Rodolfo Miranda, LinnyerBeatrys Ruiz, and Maria Luisa Amarante Ghizoni. "MannaSim: A NS-2 extension to simulate Wireless Sensor Network." ICN 2015 (2015): 107.

[38] Downard, Ian T. Simulating sensor networks in ns-2. No. NRL/FR/5522--04-10. NAVAL RESEARCH LAB WASHINGTON DC, 2004.