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Greetings!

Articles in this issue discusses about study endeavours to recent trends in E-Banking.

We look forward many more new technologies in the next month.

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COMPARATIVE STUDY OF IOT BASED MAC PROTOCOLS

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ABSTRACT—The Internet of Things (IoT) connects all over the world in many of the ways. IoT is one of the developing technologies in the recent years. WSN plays a vital role in variety of IoT applications. Wireless Sensor Network (WSN) is a network of interconnected battery-powered tiny sensor nodes that communicate wirelessly to monitor and record the physical conditions of the environment such as temperature, sound, pollution levels, humidity and wind. These collected data forward to a central location of the Sink node (gateway) where they can be processed or analyzed via the Internet. In many situations, sensors are positioned in areas where human intervention is not possible. As WSN sensor nodes operate on batteries, which cannot have an infinite lifetime and the replacement of batteries is often difficult. Network lifetime is the major issue in wireless sensor networks. Medium access control (MAC) protocol plays an important role in energy efficiency in wireless sensor networks because node access to the shared medium is coordinated by the MAC layer. Energy conservation in sensor nodes is generally achieved by duty cycling the radio. The MAC protocols are classified into four categories such as Contention-Based Protocols, Time Division Multiple Access (TDMA) Protocols, Hybrid Protocols and Cross Layered Protocols. In this study provides an analysis of some important IoT based MAC protocols and compares strength and weakness of these protocols, which gives direction to some new research towards energy strategy and provides a reference for the further research in the IoT application.

Keywords - WSN, IoT based MAC Protocols, Throughput, Energy Efficiency.

I. INTRODUCTION

The Internet of Things (IoT) refers to interconnection of physical objects that are surrounded with sensors, software and other technologies that are purpose of connecting and sharing the data with other devices over the internet. Huge number of devices connected together to construct a standard for sharing information called Internet of Things. IoT has important technologies in the 21st century.

Now days, Internet of Things (IoT) applications have very popular in various environment monitoring and industrial domains. A Wireless Sensor Network (WSN) consists of low-power, low-cost, and small-in-size sensor nodes, which have the ability to sense, measure, gather, and process information (conductivity, temperature, and pressure) gathered from the sensor coverage area. Each node contains a sensor, a radio transceiver, a microcontroller and the most important of the battery. WSN is a network of interconnected battery-powered tiny sensor nodes that communicate wirelessly to monitor and record the physical conditions of the environment such as temperature, sound, pollution levels, humidity and wind. These collected data forward to a central location of the Sink node (gateway) where they can be processed or analyzed via the Internet. In many situations, sensors are positioned in areas where human intervention is not possible. WSNs have a wide range of advantages in terms of scalability, deployment, simplicity, self-organizing capabilities. WSN is widely used in various areas ranging from Internet of Things (IoT) based Environment monitoring to Smart cities, Food quality, Industrial process monitoring, Health-care, Military, Forest fire detection, Flood detection, Health applications, Target Tracking, Intrusion Detection, Wildlife Habitat Monitoring, Climate Control and Disaster Management Etc. WSN plays a vital role in variety of IoT applications. As WSN sensor nodes operate on batteries, which cannot have an infinite lifetime and the replacement of batteries is often difficult. Network lifetime is the major issue in WSN.

Medium access control (MAC) isa sub layer of data link layer. Medium access control (MAC) protocol plays an important role in energy efficiency in wireless sensor networks because node access to the shared medium is coordinated by the MAC layer [2] and it manages the coordination between different IoT devices during exchanging of data transmission.

The MAC protocols are classified into four categories such as Contention-Based Protocols, Time Division Multiple Access (TDMA) Protocols, Hybrid Protocols and Cross Layered Protocols [10]. Contention based MAC protocols are based on Carrier Sense Multiple Access (CSMA) and Carrier Sense Multiple Access/Collision Avoidance (CSMA/CA) mechanism. Carrier Sense Multiple Access (CSMA) is to sense the channel before starting to transmit data. These kinds of MAC protocols should reduce the collisions and increase network performance. Carrier Sense Multiple Access/Collision Avoidance (CSMA/CA) mechanism comes under duty-cycle technique to control node operations. Each node periodically toggles between active mode [11] (radio is ON) and sleep mode (radio is OFF). Contention based protocols can be divided into two categories Such as Synchronous and Asynchronous. In synchronous mode, sensor nodes periodically and synchronously alternate their operation between active and sleep modes. In the asynchronous approach [8], nodes do not require synchronization and consequently, each node can wake up and sleep independently.

In Reservation based MAC protocol, the channel is segmented into super-frames, each of frames further split into a number of slots. They allocate slots to each traffic source and make sure that each node is given a guaranteed periodic access to the shared communication medium. Time Division Multiple Access (TDMA) protocols are Reservation based MAC protocols. TDMA is a channel access method for a shared communication medium in a network.

Hybrid MAC protocols combine the advantages of CSMA and TDMA based MAC protocols. Hybrid protocol divides the channel into two parts, one is control packets, here the data is sent in random access and another one is data packets, the data are transmitted in the scheduled channel.

All the above mentioned MAC protocols are mostly based on a single layered design approach. In this new approach Cross layer MAC protocol, the interaction of MAC and routing layers are fully exploited to achieve energy efficiency and multi-hop delay of data delivery for wireless sensor networks.

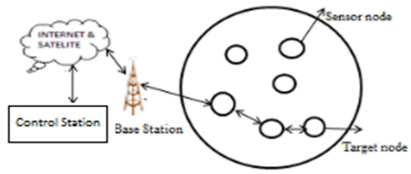

Fig :1 Wireless Sensor Network Architecture

Figure 1 show the architecture of WSN. The concept of Internet of Things goes in parallel with WSN technology. WSN technology is at the essential of accomplishing IoT architectures. In WSNs, sensor nodes are traditionally powered by small batteries with limited capacity. Hence, energy efficiency, delivery latency, Scalability and adaptability, throughput and bandwidth are very important characteristics in designing a MAC protocol.

Major Sources of Energy Depletion in WSN are Overhearing, Protocol overhead, over emitting, Collision and Idle Listening.

Overhearing**:** In WSNs, neighbor sensors can overhear packet transmissions due to the broadcast nature of the channel. When a node receives a packet destined to some other node but not addressed to it is called overhearing. After receiving the packets, the sensor node decodes it and then only the sensor node knows that the received packets are destined to it or not. This is a significant waste of energy.

Protocol Overhead: Sending and receiving control packets do not carry useful information although their transmission consumes energy.

Over emitting: The sender node is transmits data while the receiver node is not ready to receive the data.

Collision: The two or more sensor nodes attempt to send a packet across the network at the same time. It is corrupted due to interference. The transmitted packets are discarded and then follow on retransmitted, thus the retransmission of the packets takes more energy. So it increases the energy consumption and also the latency.

Idle Listening: It is occurred when a sensor node is continuously listening to the channel to receive data but not receiving anything. A node does not know when the data traffic is generated from other nodes, so its transceiver continuously stays in the receiving mode even when there is no data traffic. Continuously listening to a channel in order to detect unpredictably arriving packets or assess a clear channel is called idle listening. Most of the time the sensor node will be in idle state.

The main goal of any MAC protocol for sensor network is to minimize the energy waste due to idle listening, overhearing and collision.MAC protocols based on periodic listen and sleep mechanism can efficiently reduce idle listening. Energy efficiency and latency are vital topics in designing a MACprotocols. However, MAC protocols need to address the several challenges to provide high network throughput, less energy consumption and low latency. This paper compares the contention based asynchronous MAC protocols that are used in IoT applications and provides the strength and weakness of these protocols. First, several IoT based MAC protocols are examined in detail and then compare these protocols with one another. In this paper is organized as follows: MAC protocols for IoT application are described in Section II. Characteristics of energy efficient MAC protocols are defined in Section III. IoT based MAC protocols are presented in Section IV. Comparison of IoT based MAC protocols are presented in Section V. Open research issues are described in Section VI. Finally conclude the Section in VII.

II. NEED OF MAC PROTOCOLS FOR IOT APPLICATIONS

The Internet of Things (IoT) is probable to have the entire physical organization connected with information and communication technologies through the use of WSN sensors [14]. IoT applications have increased in both of industries and people's daily life. IoT MAC protocols to achieve high reliability and low overhead, these protocols provide high performance under high traffic loads. IoT based MAC protocols forceful in dynamic and noisy environment [7]. IoT base Mac protocols ported easily into new devices and these protocols easily supported into devices. Many of the authors proposed MAC protocols for IoT Applications. Likewise IoT in healthcare is proposed in Mavrogiorgou.A et al (2019). An Energy Efficient and Secure IoT Based WSN Framework are proposed in Haseeb K et al (2020).PRIB-MAC protocol was proposed in R Anubhama et al (2020). QX MAC protocol proposed in Farhana Afroz et al (2021).RIVER proposed in L. Wymore et al 2019, this protocol is more suitable for high density IoT applications. QL-based MAC protocol is proposed in CHIEN-MIN WU et al 2021. VTA –SMAC protocol was proposed in Masood UR Rehman et al (2021) etc.

However, the intelligent devices of IoT sensors are typically energy constrained and need to process the complex computation. Therefore, the permanence of the WSN is one of the primary design factors for IoT applications and recent research area. In this section, the IoT based MAC protocols are investigated in detailed. The recently described MAC protocols are focused in this paper.

III. CHARACTERISTICS OF ENERGY EFFICIENT MAC PROTOCOLS

A well designed MAC protocol must need to adopt energy efficient techniques that try to minimize the major causes of energy consumption, the following attributes are to be considered.

Energy Efficiency

Wireless Sensor nodes are small and battery powered [12], it is very difficult to charge and replace [4]. Sometimes replace the sensor node rather than recharging them. Thus the MAC protocol should be designed such that it consumes energy efficiently to support network lifetime.MAC protocols achieve energy efficiency by turning off the radio when the node is not transmitting or receiving any packet.

Scalability and Adaptability

WSN MAC protocols should be adaptable to changes in network size, node density and topology. These changes can be attributed to mobility and failure of nodes and support network lifetime.

Latency

Latency means the amount of time taken by the packet to reach the sink node [9]. In the WSN sensor network applications, the noticed actions must be conveyed to the sink node in real time so that the appropriate action could be taken immediately.

Throughput

Throughput tells the amount of data flow in the network that is successfully received by receiver from source at a given amount of time.

Bandwidth

Bandwidth tells how much data rate in a network. We can't restrict speed of a network by only the network bandwidth. Network should support higher bandwidth utilization.

IV. LITERATURE REVIEW

1. RIVER

RIVER's proposed in L. Wymore et al 2019, this protocol is more suitable for high density IoT applications. RIVER-MAC [7]is a Receiver – Initiated asynchronous duty-cycled MAC protocol. RIVER mainly focuses on a CCA-based rendezvous and a beacon train-based collision resolution scheme. CCA (Clear Channel Assessment) -based rendezvous is reducing idle listening and a beacon train-based collision resolution scheme to reduce contention between receivers. CCA is used to detect energy on the channel. When activity is detected, the sender goes to receive mode in order to receive the next packet.

Fig. 2 describes the CCA based rendezvous. Sender is strobes Clear Channel Assessment to detect any energy on the channel instead of waiting for beacon from receiver. This mechanism is to reduce idle listening. Receiver node can send two beacons; one is initial beacon for the sender to sense with a CCA, and a second is regular beacon for the sender to actually receive. Consequently, the CCA based rendezvous decreases the sender's load and increases the receiver's load.

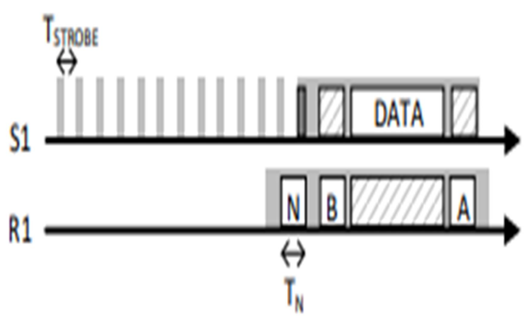

Fig: 2 The CCA-based rendezvous. N is an initial beacon and B is regular beacon

Beacon Train-based Collision Resolution scheme is to addresses the problem of contention between receivers.

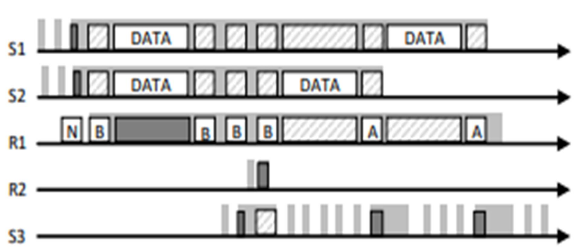

Fig: 3 Beacon train based collision resolution

Fig 3 shown as, wake up receiver only reserve the channel resource so additional receivers cannot use it; in this way avoid the contention. The wake up receiver transmits a train of regular beacons, instead of remaining receiver silent, during the back off portion of the sender collision resolution process. If any other receiver wake ups to send beacon during this time, it will notice one of the beacon packets in the train from the active receiver and this receiver reschedule the own beacon transmission.

RIVER effectively controls the tradeoff between the energy saved by the sender via reduced idle listening, and the additional energy overhead of the receiver due to having to transmit the initial beacon. Less energy spent idle listening when sending, but more energy spent on periodically transmitting the initial beacon. Thus, RIVER-MAC may not be appropriate for require delays few milliseconds or faster applications. These types of applications should use a scheduled synchronous based protocol. RIVER-MAC's used in opportunistic cross-layer approach could be improved in energy performance.

2. PRIB-MAC

PRIB-MAC protocol is proposed in R Anubhama et al (2020).PRIB-MAC [3]protocol is alternate of the RI-MAC. RI-MAC [5] handle the unicast data but PRIB MAC handles broadcast data. The PRIB-MAC protocol is mainly designed for handling broadcast traffic efficiently instead of multiple unicast. PRIB-MAC protocols use both preamble base sender-initiated approach and beacons of the receiver-initiated approach. Receiver first send beacons signals to sender, when the sender receiving the beacon, afterwards sender is sending a short preamble to the receiver before broadcasting of data.

During the preamble interval, the sender broadcasts the data to the receivers. PRIB-MAC uses a NACK (Negative Acknowledgement) beacon to certify reliability and avoid acknowledgement explosion problem. If the receiver does not receive the data after receive the preamble, it sends the NACK beacon to the sender for requesting retransmission. The main objectives of PRIB-MAC protocol are reduce the number of transmissions, reduce the broadcast latency, reduce the energy consumption of sender and reduce the number of collisions by addressing the hidden terminals effectively but receiver waits for data much amount of time, it consume more energy.

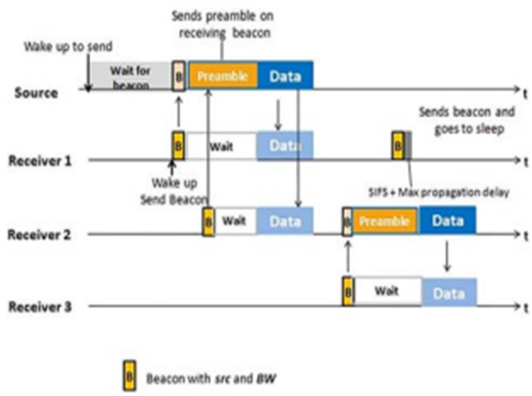

Fig: 4 PRIB-MAC

PRIB MAC protocol is illustrated in Fig 4. The Source node is wake up to wait for beacon from neighbouring node. Receiver 1 send beacon to source node, then source node send short preamble and delays to send broadcast data. During the preamble interval receiver 2 also wake up and send beacon. After the preamble interval receiver1 and receiver 2 is getting the data from source and broadcast the data to the rest of the nodes in neighbourhood.

3. QX-MAC Protocol

QX MAC is a sender initiated protocol proposed in FarhanaAfroz et al (2021). The objective of the QX-MAC protocol [6] is to improve QoS without limiting the energy efficiency of WSNs. QX-MAC combines the Q-learning algorithm and the more bit scheme to enhance the overall performance of the network. The QX-MAC protocol uses the strobed preamble mechanism like that X MAC. QX-MAC is dynamically adjusts the active period and duty cycle of the sending and receiving nodes according to the sender's traffic loads. Sender reserves its active period based on its queue status using Q-Learning and the receiver adjusts its duty cycle using the more bit scheme. Fig 5 shows the operation of QX MAC protocol. A Wakes up node enters into the CCA state to check the any activity in the medium. During the CCA period, if no activity is detected, the node checks its queue status after CCA timer expires. When node's queue is not empty, it moves to SEND_PREAMBLE state after starts to transmitting a series of short preambles. Receiver send back an acknowledgment (PACK) to the sender when the intended receiver detecting a short preamble.

On receipt of the PACK, the sender stops to sending short preambles and move to the SEND_DATA state to transmit a data packet. If the sender has more packets in its queue for the same receiver, it sets more bits to 1 in its data frame, in this manner signaling the receiver to extend its active period for the next data packet from it. The sender waits for the data acknowledgment (DACK) from its receiver.

If DACK is not received within certain duration, the sender retransmits the data packet. If DACK is received at the sending end, the sender use the Q-learning algorithm to reserves its active time to transmit its subsequent data packet(s).As the initial state, the sender maintain the queue status, i.e., the number of packets queued for transmission, using the epsilon-greedy method to chooses an active period (action) from the action space, and sequentially transmits the next data packet(s) within the allocated active period. At the receiving end, after receiving each data packet, the indented receiver reads the more bit. If more bit = 1, it extends its active period. Whenever the receiver finds the more bit = 0, indicating the current sending node has no more packet to transmit, the receiver switches to SLEEP state.

Network achieves the minimum packet loss with QX-MAC, so it's enhancing the reliability. Each preamble packet carries the intended receiver's ID; the non-intended receivers can turn off their radio after receiving a preamble. Its avoid overhearing problem.

Early acknowledgment problem consume waste of energy. With a lesser number of nodes, the queue length at each node as well as the contention delay becomes smaller. As the number of nodes increases, both the queuing delay and contention delay increase since a sender needs to contend with more nodes to access the medium; and this leads to the higher probability that a node will have a longer queue.

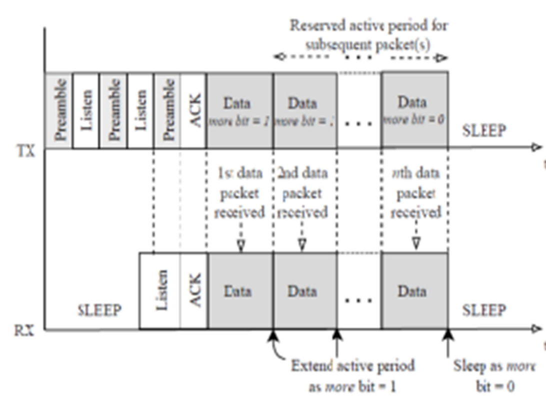

Fig 5: QX MAC PROTOCOL

4. QL-Based MAC

QL-based MAC protocol is proposed in CHIEN-MIN WU et al 2021. It is an adaptive adjustment of the length of the contention period in response to the ongoing traffic rate in IoT networks [1]. QL-based MAC was uses of Reinforcement Learning algorithm to dynamically adjust the length of the contention period according to the traffic rate. High collision probability will occur in high traffic environments when the length of the contention period was fixed (Short in contention period). Furthermore, there was high propagation delay will occur in low traffic environments for long lengths in the contention period. This protocol is mainly proposed for a traffic-adaptive MAC protocol for IoT networks. Q-Learning algorithm enables the cluster head to select the appropriate length of the contention period in the network based on experience gained from agent-environment interactions.

QL-Based MAC protocol control channel are shown in Fig 6. Here, Two Phases of beacon interval are described; there are contention period and data periods. Contention period first send RTS control frame, after which the cluster head transmits the broadcast slot transmission confirm (BTC) control frame and the length of the next contention period to all cluster members. The successful IoT nodes perform data transmission afterwards.

Phase 1: Contention period: RTS and BTC control frame are involved. Initially, set the length of the contention after which the length is adjusted according to actual traffic rates using the QL algorithm. New denotes a node when this new node adapted to the network.

Phase 2: Data period: Over the contention period, all successful IoT nodes can transmit data based on the BTC control frame.

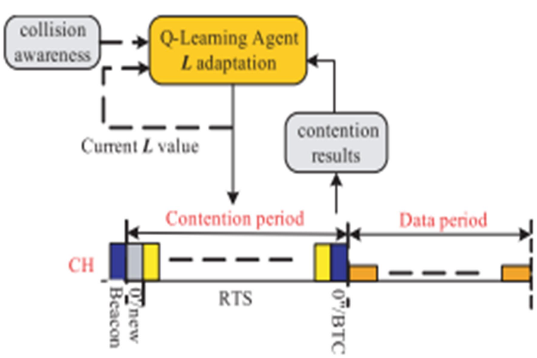

Fig 6: Q-Learning Based Adaptive MAC protocol

The QL-based MAC protocol was maximizing the system throughput and minimizes the propagation delay through the QL-based scheme that adaptively regulates the length of the contention period. QL-based MAC protocol has higher system throughput, lower end-to-end delay, and lower energy consumption in MAC contention than those of contention-based MAC protocols. This receiver initiated protocols Beacon interval is more, it consume energy.

V. COMPARISON RESULT

In this section, IoT based MAC protocols are compared with each other. Table 1 compares the strength and weakness of MAC protocols for IoT.

Table 1

MAC	CONCEPT	STRENGTH	WEAKNESS
RIVER	RIVER mainly focuses on a CCA-based rendezvous and a beacon train-based collision resolution scheme.	1. Reduced idle listening. 2. Reduce contention between receivers.	1. Spent more energy on periodically transmitting the initial beacon. 2. RIVER-MAC may not be appropriate for require delays few milliseconds or faster applications.
PRIB	Handling broadcast traffic efficiently. Sender & Receiver Initiated Protocol	1. Reduce the number of transmissions. 2. Reduce the broadcast latency. 3. Reduce the number of collisions effectively.	1. Receiver waits for data more amount of time, its consume more energy
QX	Sender initiated protocol. Combine Q-learning and more bit scheme to enhance performance	1. Minimum packet loss. 2. Achieve reliability 3. Avoid overhearing problem	1. Early Acknowledgment problem occur 2. Both the queuing delay and contention delay increase when increasing number of nodes
QL	QL algorithm used to adjust the length of the contention	1. Higher system throughput 2. Lower end-to-end delay	1. Beacon interval is more, it consume energy.

VI. OPEN RESEARCH ISSUES

Recently many of the MAC protocols proposed for IoT applications. This paper compares these four types of protocols are comes under Contention-Based Protocols. Each of the protocols has some strength and weakness. While Contention Based MAC protocols for WSN adopt low duty cycling to achieve energy efficiency and can be broadly categorized into synchronous and asynchronous duty cycle protocols. In the asynchronous duty cycle protocols wake up based on their own schedule and several mechanisms are proposed for coordination of source and receivers to complete the transmission of data. Asynchronous protocols further divided into

Sender –initiated and Receiver – initiated protocols. Based on the comparison, open research issues are identified.

1. Idle Listening: In the Sender initiated protocols, sender waiting for receiver wakeup more amount of time, so idle listening occurs in sender side.

2. Node Coverage: Time taken to cover the number of nodes in network is more. If very less time is take to cover the number of node in network, then can improve the energy efficiency.

3.Packet Overhead: Excessive control packet or beacon packet or preamble signals exchanges will consume a significant amount of energy. Due to the Control packet overhead that may shorten the network lifetime. Hence, a MAC protocol which needs a very less number of control packet transmissions is preferred.

4. Retransmission: Poor channel utilization will increase the number of re-transmission. Hence, before sending a packet, must want to check the channel quality.

The assessment of sender-initiated and receiver initiated MAC protocols under a common framework is still an open research area.

VII. CONCLUSION

Main challenging problem is designing a MAC protocols for IoT application which can improve energy-efficiency to prolong network lifetime [13] in wireless sensor networks. IoT based MAC protocols have been technically investigated in this paper. Each of the MAC protocols has reviewed in terms of concept and characteristics and then compares the each of the protocols strength and weakness. Our future work will be aimed to designing MAC protocols for IoT which can give better use of trade-offs between performance metrics, such as energy efficiency, end-to-end delay, accuracy, reduced network overhead and throughput.

REFERENCES

[1] Chien-Min Wu , Yen-Chun Kao, Kai-Fu Chang, Cheng - Tai Tsai, and Cheng- Chun Hou "A Q-Learning-Based Adaptive MAC Protocol for Internet of Things Networks". Digital Object Identifier 10.1109/ACCESS.20213103718.

[2] A. Kumar, M. Zhao, K.-J. Wong, Y. L. Guan, and P. H. J. Chong, "A comprehensive study of iot and wsn mac protocols: Research issues, challenges and opportunities," IEEE Access, vol. 6, pp. 76228-76262, 2018.

[3] R. ANUBHAMA and T. RAJENDRAN, "PRIB-MAC: a preamble-based receiver initiated MAC protocol for broadcast in wireless sensor networks", Sådhanå (2020)45:79.

[4] F. Afroz and R. Braun, "Energy-efficient MAC protocols for wireless sensor networks: a survey," International Journal of Sensor Networks, vol. 32, no. 3, pp. 150-173, 2020.

[5] P RachelinSujae, S Arulselvi, "Receiver-Initiated Medium Access Control (RI-MAC) Protocols" International Journal of Innovative Technology and Exploring "Engineering (IJITEE) ISSN: 2278-3075, Volume-8 Issue-8, June 2019.

[6] FarhanaAfroz,and Robin braun, "QX-mac: improving QoSand energy performance of IOT-based wsns using Q-Learning". In Proceedings of the 2021 IEEE 46th Conference on Local Computer Networks (LCN), Edmonton, AB, Canada, 4-7 October 2021;pp. 455-462.

[7] Mathew L. Wymore and DajiQiao, "RIVER-MAC: a Receiver-Initiated asynchronously duty-cycled MAC protocol for the internet of things".In Proceedings of the 2019 IEEE 43rd Annual Computer Software and Applications Conference (COMPSAC);vol 1,pp. 860-869, July 2019.

[8] Y. Sun, O. Gurewitz, and D. B. Johnson, "RI-MAC: a receiver-initiated asynchronous duty cycle MAC protocol for dynamic traffic loads in wireless sensor networks," in Proc. ACM SenSys, 2008.

[9] X. Fafoutis, A. D. Mauro, M. D. Vithanage, and N. Dragoni, "Receiver-initiated medium access control protocols for wireless sensor networks," Computer Networks, vol. 76, pp. 55–74, 2015.

[10] Anubhama R and Rajendran T 2017 A survey on MAC protocols for wireless sensor networks. In: Proceedings of the Second International Conference on Research in Intelligent and Computing in Engineering, pp. 121–126.

[11] Djiroun, F.Z.; Djenouri, D. MAC protocols with wake-up radio for wireless sensor networks: A review. IEEE Commun. Surv. Tutor. 2016, 19, 587–618.

[12] Quintero, V.; Estevez, C.; Orchard, M.; Pérez, A. Improvements of Energy-Efficient Techniques in WSNs: A MAC-Protocol Approach. IEEE Commun. Surv. Tutor. 2018, 21, 1188–1208.

[13] Sadeq, A.S.; Hassan, R.; Sallehudin, H.; Aman, A.H.M.; Ibrahim, A.H. Conceptual Framework for Future WSN-MAC Protocol to Achieve Energy Consumption Enhancement. Sensors 2022, 22, 2129.

[14] Guo, F.; Yu, F.R.; Zhang, H.; Li, X.; Ji, H.; Leung, V.C. Enabling massive IoT toward 6G: A comprehensive survey. IEEE Internet Things J. 2021, 8, 11891–11915.


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