Receiver-Initiated Medium Access Control (RI-MAC) Protocols

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Abstract*: *Medium Access Control (MAC) protocol is one of the major elements in the construction of the Wireless Sensor Networks (WSN), and it is used for system governing of some portion in which when and how two autonomous neighboring nodes initiate their particular receivers for the direct interactions. Generally, data replace has dependably been started by the node keen to hand-off information, for example, the sender. Though, the Receiver Initiated (RI)model has produced a different course of research, conceding many new MAC protocols. Inside such a model, the receiver is the one responsible for beginning an immediate communication with a qualified sender. This takes into consideration of new helpful properties to be fulfilled, novel plans to be initiated and new difficulties with being handled. This article proposes a complete review of all the MAC protocol related to RI classification. Specifically, remembering the fundamental difficulties that RI-MAC protocols are intended to manage, this paper analyses and discusses the various protocols as indicated by regular highlights and plan objectives.

***Index Terms*: *WSN, MAC, Receiver Initiated Protocols*.**

I. INTRODUCTION

In WSN, MAC plays a important role. It is predominantly reliable for the formation of communication link among the nodes which are essential to creating a network infrastructure. The MAC structure then controls the access of the shared wireless channel by using numerous nodes [1]. Compared with the existing networks where the main priority is given to the bandwidth efficiency and Quality of Service (QoS), energy efficiency is the major objective of WSNs, rendering conventional MAC methods inapplicable [2]. Meanwhile, the transceiver of the sensor node exploits the maximum power compared to other components of the node which is controlled by the duty cycle [3]. The duty cycles can be defined as the sleep state and active state condition of the sensor node where the node is in ON condition in active state and OFF condition in sleep state [4]. Also, the WSN can be classified into asynchronous and synchronous methodology [5] based on the rendezvous point where the communicating nodes meet at active state thereby authenticating the linkage. The synchronous scheme relies on the pre-fixed schedule time periods. In both the schemes, the communications between two nodes take place at the active state by synchronization [6].At a rendezvous point, whenever a sender node has information to forward, it holds up until the active condition to start the information transfer. The synchronous systems are very tolerant of planning misalignment, being that as it may, regardless, they require an all-around synchronized plan, which makes an extra energy overhead. Also, the cost of the synchronous protocols related to the formation and maintenance of the scheme [7]. Moreover, the node coupling through a worldwide clock likewise prevents the capacity of a node to have a completely free duty cycle. Whereas, in asynchronous scheme it does not need synchronization, as the nodes wake-up and sleep independently [8].This urges for designing strategies for creating a rendezvous point for communication. In asynchronous scheme, two techniques are followed: the receiver -initiated and the sender -initiated technique [9]. The strategy utilized in a sender-initiated technique is called as the introduction sampling where the sender forwards a beacon to exhibit that there is a pending data for communication [10].Here, the receiver node awakes often to check for any introduction signal. When the introduction communication is recognized, the receiver nodes affirm to the sender node when the initial transmission ends. This binds the communication amongst the sender and receiver nodes [11]. The application of sender-initiated technique is applied in [12].The receiver initiated is opposed to the preamble sampling strategy utilized in sender-initiated methods. Here, the receiver-initiated technique utilizes transfers the beacon signals in a period that is characterized by its duty cycle and is utilized by the sender for synchronizing with the receiver.In the asynchronous technique, the RI model was considered as more energy efficient compared to the sender-initiated model. This paper delivers a comprehensive review of the different MAC protocols under the receiver-initiated class. The remaining portion of this paper is as follows in section 2 presents the challenges of RI-MAC protocols, Section 3 explains all the conventional RI-MAC protocols, and finally, Section 4 concludes the review.

II. CHALLENGES FOR RI-MAC PROTOCOLS

The communication between any two nodes in WSN is controlled by the MAC protocol share through a common medium. For such communications, the protocol overhead must be kept minimum: both for radio transceiver and data exchange.

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Though the objectives are distinctive among sensor-based sensor networks, it dominates and creates expectancy for increase in throughput and network lifetime. However, acknowledgment and re-transmission are hardened methods in all conventional WSN. Additional challenges for instance like managing the duty cycling amongst the dynamic and static state to save energy is still the scope of the research in WSN. The major challenges in RI-MAC protocols are Inactive listening, Collision prevention, Adaptive duty cycling, Broadcast communication, Asymmetric links, QoS (Quality of Service), and Security.

III. RECEIVER-INITIATED MAC PROTOCOLS

The RI model asynchronous communication to duty cycle nodes was presented by RICER [14] in 2004. In 2008, a RI approach, called as Low Power Probing (LPP) was well-defined in [29], which utilizes the RI model for the need of waking up all sensor nodes, though it is not related with the actual data transfer. The RI-MAC paradigm of communication is shown in figure 2. Here each node wakes-up periodically to check for incoming data packets. Node B (receiver node at instance) announces its neighboring nodes in the sensing region (node A & node C) that it is READY to accept the data packets by broadcasting a base beacon and waits for a short duration to receive the data packets. This base beacon frame acts like a trigger to establish data communication between two nodes. If no data packet arrives during this period, the receiver node A will go to SLEEP state. On the other hand, if the sender node has a data packet in the transmission queue, the sender node enters into active state and listens to the channel for the base beacon frame from the intended receiver node B. Once it receives the base beacon, the sender node forwards the data packets in the transmission queue until the timer expires in node B and the receiver node sends an acknowledgement frame. The acknowledgement frame plays a dual role as acknowledgement to the previous data packet, as well as request to initiate the next data packet transmission incase the sender node has pending data packets to send in the transmission queue. Meanwhile, if a contending node (node C) tries to access the channel at the same time, the data packets collide with each other and the node transmits the frame after a random back-off. Hence, the transmission challenges of the contending nodes lead to maximization at the cost of collision. In addition, the RI-MAC paradigm visibly shows that the idle listening period of the sender nodes can be significantly reduced if the sender node predicts the receiver node's wake-up schedule and wakes up slightly before the receiver node. Another property of the RI-MAC is that the sender can request a base beacon frame from an intended receiver. This request from sender is a beacon frame with Back-off window (BW), which acts like RTS (Request-to-Send) and if the intended receiver is awake, it replies with a base beacon frame. In Figure 1(b), sender node A sends a beacon request to its contending receiver node B to initiate the data transmission by sending a base beacon. Rest of the mechanism follows the normal mechanism of Figure 1.(a).

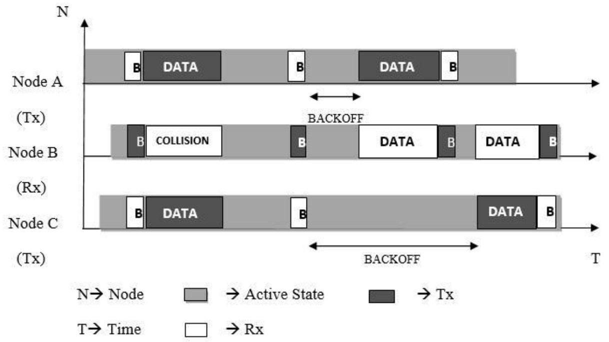

Fig.1a RI-MAC Beacon Transmission with Back-off window

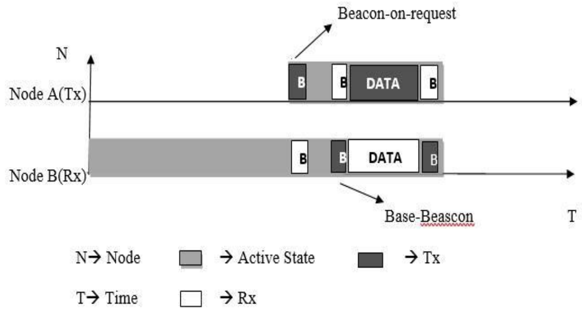

Fig.1b RI-MAC Transmission with Beacon-on-request

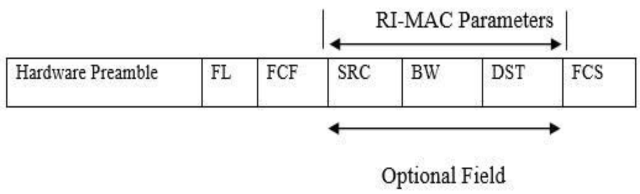

Fig.2 RI-MAC Beacon Frame Format for IEEE 804.15.4 transceiver. The Standard fields of IEEE 804.15.4 – FL (Frame Length), FCF (Frame Control Field), FCS (Frame Check Sequence)

IV. EXPERIMENTAL RESULTS & DISCUSSION

The comparison of various RI-MAC protocols is given in Table.1.

Table.1 Comparison of various RI-MAC protocols

Name of the protocol	Features
Stat topology RI-MAC (STRI-MAC)	❖ The model has a wide application scope. ❖ Immersion throughput ❖ Low power utilization
Opportunistic Direct Interconnection RI-MAC (ODI-RIMAC)	❖ Minimal overhead in terms of memory and energy. ❖ Scalability, network capacity still to be addressed.
Opportunistic Wake-Up MAC (OPWUM)	❖ Timer-based contention is a powerfully remarkable solution. ❖ Potential receivers were selected utilizing a routing algorithm not focused.

Receiver-Centric Scheduling MAC (RCS-MAC)	❖ Throughput was significantly enhanced by receiver-centric scheduling. ❖ Parallel data gathering with multichannel support. ❖ Improved energy efficiency.
Receiver-centric scheduling	❖ Improved throughput. ❖ Better energy efficiency. ❖ Reduction in duty cycle and the drop of a packet.
Adaptive and Dynamic Polling based MAC (ADPMAC)	❖ Operates best for the Poisson Arrivals. ❖ Performance degrades with the increasing mismatch between the instants of preamble transmission and channel polling.
Energy-Efficient and Traffic-Adaptive Z-MAC (EETA-ZMAC)	❖ Balanced the load ❖ Prolonged the lifetime of the network ❖ Total energy consumption is less.
Energy Efficient asynchronous multichannel RI-MAC (EE-RITMC)	❖ Better delivery rates when network throughput was not so high. ❖ Significant improvement in terms of consumption in relation.
Receiver-initiated Consecutive Packet Transmission Wake-up radio(RI-CPT-WuRMAC)	❖ Successful transmission probability. ❖ Low energy consumption.
Bird-MAC	❖ Energy-efficient in communication. ❖ Problems insecurity and time synchronization
Predictive Wake-up Multi-Channel MAC (PW-MMAC)	❖ Achieved multichannel rendezvous without the need for any control channel. ❖ Attained low duty cycle, low latency. ❖ 100% delivery ratio in all scenarios.
Pseudo-Random Precoder	❖ Low-complexity. ❖ Near-optimal results. ❖ Rely on eliminating the inter-sensor communication
self-Learning MAC (L-MAC)	❖ Design is very easy and simple to implement. ❖ Higher energy efficiency
Self-Adaptive Sleep/wake-up scheduling	❖ Does not use the duty cycling technique. ❖ Based on game theory and the reinforcement learning method
S-MAC protocol	❖ Energy consumption is reduced on the sensing phase and the transmission phase. ❖ Delay was totally removed from the queue.
Traffic Estimation-based RI- MAC (TERI-MAC)	❖ Stable energy efficiency with varying traffic patterns. ❖ Promising MAC solution for delay-tolerant underwater applications
Traffic-Adaptive Receiver-Synchronized random access protocol(TARS)	❖ Better network throughput, ❖ Efficient packet end-to-end delay ❖ robustness to mobility ❖ Highly appropriate for mobile and traffic-varying UWSNs.
Combined Free and Demand Assignment Multiple Access (CFDAMA)	❖ Significant enhancement in the overall delay/utilization performance. ❖ Better delay performance.
iQueue-MAC	❖ Can learn the traffic load more accurately. ❖ Maintains high efficiency as it mitigated contention and retransmission.
Adaptive Duty-cycled hybrid XMAC (ADX-MAC) protocol	❖ Average Throughput ❖ High energy efficiency
Traffic-aware dynamic MAC protocol (TAD-MAC)	❖ Delivery ratio can be reduced up to 70% before a node reaches a convergence state.
Demand Sleep MAC (DS-MAC)	❖ Decrement in waiting time. ❖ Performance of the network is high.
QoS MAC protocol for Prioritized Data in EH-WSNs (QPPD-MAC)	❖ Impressive reduction in the average end-to-end delay of priority data packets. ❖ Reduction of all data packets in both higher and lower solar irradiance situations.
Wake-up Variation Reduction Power Manager (WVR-PM)	❖ Significant reduction in the average number of wake-up variations.
Slot Stealing SS-MAC	❖ Provided a deterministic delay guarantee performance. ❖ Better performance in delay and channel utilization.
PRIority in Node (PRIN) MAC [57]	❖ Superiorpacket rate of throughput received with no interference.
QoS-aware Omnidirectional Antenna-based MAC (QODA-MAC)	❖ Lower latency ❖ Higher throughput with less energy consumption
Self-Stabilizing Hop-constrained Energy-efficient (SHE)	❖ Lower power dissipation ❖ Longer network lifetime
Cascade Self-Tuning control (CSFD)	❖ Higher throughput with the same total power consumption, ❖ More efficient power usage for frame transmission.
Effective Multi-hop Broadcast protocol for asynchronous Multi-channel WSNs (M-EMBA)	❖ Energy efficiency is high. ❖ Broadcast success ratio is high. ❖ Better multi-hop broadcast latency.
Delay-Sensitive multi-channel MAC [DSMMAC]	❖ Better performance in end-to-end delay, packet delivery ratio, and energy utilization. ❖ Higher delivery reliability. ❖ Lower energy consumption.
Reservation Mechanism multi-channel MAC protocol (RM-MAC)	❖ Mitigation in the multiple-senders-single-receiver issue. ❖ Improvement in packet delivery latency and energy efficiency.
Multichannel MAC Underwater Acoustic Sensor Networks MC-UWMAC.	❖ Did not require any extra packets exchange between nodes. ❖ High energy efficiency
Optimized Multi-Transmission Receiver Initiated (OMRI)	❖ Significant increase in the number of packets. ❖ High performance compared to RI-MAC.
Authenticated Key Exchange (AKE) - Randomized Authentication Primitives (RAP)	❖ Provides high level of security. ❖ Low energy consumption.

Energy Efficient Routing and Fault-Tolerant Data Aggregation (EERFTDA)	❖ High transmission rate, ❖ Events duration is less. ❖ Low energy consumption. ❖ High aggregation accuracy.

V. CONCLUSION

This paper furnished a comprehensive evaluation concerning the various receiver-initiated MAC protocols for WSNs centered on their one of kind residences. The predominant goal of this work is to furnish the interested researcher with adequate insight into each and every protocol so that extra review of the vital literature can also be implemented autonomously. Wi-fi sensor networks continue to be a scorching subject, and new and intriguing ideas are being proposed consistently. A exact procedure would be very good in a single state of affairs and disastrous within the next one. Below these assumptions, this evaluate supplied a excellent instrument to list the entire present suggestions, providing with a establishing factor from where required functionality can also be combined and matched in order to craft a solution that flawlessly fits the necessity of the current software.

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