**CHAPTER 5**

**Implementation**

**5.1 Implementation of objectives**

In wireless sensor networks power saving is considered as one of the significant challenges. The time and efficient power management needs to be balanced using the resources and network requirements in wireless sensor networks. The three MAC protocols are developed for efficient power management, time synchronization and network performance. Most of the MAC protocols are used for the energy efficiency consideration and the protocols implemented in this research helps in achieving the throughput without sacrificing the energy efficiency.

The research objectives used in the work are as follows,

1. To find intrinsic energy limitations of wireless networks for new energy-efficient time synchronization in multiple nodes.
2. To investigate the trade-offs between time synchronization accuracy and energy saving in WSN.
3. To develop a protocol or algorithm for determining the optimal synchronization period to save energy in multiple nodes.
4. To enhance state-of-the-art through exploring new method to save energy while assuring high flexibility and reliable operation of WSN through the protocols.

The proposed protocols such as receiver centric MAC protocol (RC-MAC), Improved receiver centric MAC protocol (IRC-MAC) and Intelligent traffic and resource elastic energy MAC (Itree-MAC) protocol are designed using few parameters and is represented. The receiver centric MAC protocol increases the network throughput by assigning the different node sets with different links than with the different channels. The improved RC-MAC protocol helps in evaluating the performance considering the parameters such as energy consumption, end to end delay in sensor nodes and throughput in wireless sensor networks. An efficient Intelligent Traffic and Resource Elastic Energy (Itree-MAC) protocol is developed to enhance the performance of the communication system by proper routing and allocation of the resources. The design parameters used for these protocols is discussed below.

* 1. **Proposed techniques and mathematical models**

5.2.1 RC-MAC

The tree structure in RC-MAC with different schedules time slots to different children is shown below.

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| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |
|  | 2 |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  | 3 |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  | 4 |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  | 1 |

 S1 P S2 P S3 P S4 P

* Data -Ack

 Fig. 1: RC-MAC schedules time slots to different children based on overhearing

The tree structure in RC-MAC is shown above. The process is as explained where the receiver always schedules its packet transmissions by reusing the ACK. The ACK signal is sent to one of its children can be overheard. The scheduling of the children’s packet transmissions by piggybacking a message which is considered as ID of the child which can send a packet to an ACK as shown in the above figure. RC-MAC operates as a pulling data rather than the traditional pattern of pushing data.

The main design goal is to improve the communication throughput under different traffic loads by considering the tree structure in WSN. The design challenges observed in this kind of protocol is, as the protocol is an unbalanced tree structure, it is having the different nodes with different bandwidth demands and thus the nodes are assigned with different chances for the channel accessing.

* Adapt to low duty cycle

The RC-MAC which is designed should be effective under different traffic loads. If there is any occurrence of traffic loads it leads to long burst of the data packets. To improve the energy efficiency, RC-MAC is enormously adapted to the duty cycling techniques (Polastre et al., 2004). The nodes present in the protocol turn their radio on between the active and sleeping states. The RC-MAC is designed usually under the light traffic loads and the proposed is shown to be better than the previous ones such as X-MAC (Yee et al., 2006) and B-MAC (Sun et al., 2008). Once the node gets up it initiates or broadcasts a beacon to notify the neighbouring nodes. The channel access is obtained when the multiple senders contend for receiving the beacon. This protocol does not help in rebroadcasting a protocol with the increased back off window size when collision occurs as the extra overhead does not brings any throughput gain. The senders in the RC-MAC tries with the binary exponential back off if an ACK times out. The other side has a node which stays awake if it has pending data to send.

5.2.2 Channel access scheduling



 Fig 2. An example of RC-MAC and its representation. (Chen et al., 2010)

The nodes operate in the low duty cycle where the node helps in broadcasting a beacon when it is awake. When data packet is received the parent, node responds an ACK which contains the ID of the next sender. As soon as the ACK is received from its parent the child node will be transmitted, Whereas the neighbour nodes will stop sending for some period of time and start for contention if the receiver flag is set as active.

Considering above figure as an example, A1 wins channel access and helps in transmitting a packet to P1 upon receiving the beacon from P1. The nodes present in the unit C cannot transmit as it is not in the interference range of unit A. P1 responds to an ACK to A1 when receiving the packet from A1. If the channel is clear it sends the packet. If they don’t have data to send due to busy channel the timers will expire.

5.2.3 Account for different bandwidth demands

Let bu denote the total bandwidth demand for node u and du represent the data generated by node u. The total bandwidth demand of node u is equal to the total bandwidth demand of u’s tree and also the data rate. The heavy traffic nodes always get more channel access opportunities

5.2.3 Collision among units

The benefits of the RC-MAC are to maximize the interferences among the units Few nodes are not able to sense the transmission of the other units and trigger the receiver centric scheduling. The ongoing scheduling is maintained by the time priority and capture effect exception. As observed in the above figure 2, A1 wind the access of the channel and B3 is not in the interference range of A1 and transmit a packet to P2. The receiving of the P2 may be interrupted by the ACK of the P1. The probability of collision is reduced by the scheduling. The channel utilization is improved by allowing the compatible units transmit the data simultaneously.

5.2.4 ACK frame

The beacon frame is used whenever the node wakes up. The aim is to mention the neighbouring nodes that it is receiving the packets. It contains the src field and Dst field and NX field which specifies the next sender. The ACK frame and the beacon frame are integrated together and the nodes are distinguished according to the length of the frame.

* 1. Data transmission of the RC-MAC protocol.

The reliable data transmission in WSN is ensured by the retransmission mechanism. The lost packets in the process is retransmitted by the time-out mechanism. The sender waits for an ACK after sending a packet to the receiver and if the ACK is not received then the retransmission occurs. The packet which is lost in the mechanism is transmitted multiple times up to a few thresholds. The second part of the RC-MAC design, has different packets which is collectively called as group with one ACK. The lost packet is retransmitted and the number of the ACK is reduced. The lost packets are detected between a side and receiver and the mechanism used is the sequence based which helps in labelling the packets sent in a group with different continuous sequences and the packets lost in the mechanism can be detected by the receiver. The RC-MAC protocol applies the sequence-based mechanism in a hop to hop manner to obtain the reliable data transmission from many sources to a sink.

5.3.1Streaming the data transmission from multiple sources to A sink

RC-MAC which is designed to maximize the throughput from multiple sources to sink. Thus, the RC-MAC helps in streaming the packet transmission where the retransmission of the lost packets does not occur. As the sequence-based mechanism cannot maintain a continuous data forwarding stream as it follows the continuous sequences which is looked after between the source and the sink. The interruption which occurs in the intermediate node will stop forwarding of the data. Thus, a localized numbering mechanism can be used to label each packet each hop.

* + 1. Request of the lost packets

The node sends few packets in group and one byte of the field is attached to the ACK for requesting the lost packets. The bit helps in representative of a packet in the group where 1 means it is received and 0 means lost. If the lost packet is obtained the recovering of the lost packets is done with the time complexity. In RC-MAC the queue is divided into three regions such as sending region, the receiving region and the recovery region. The sending region consists of all the packets that are wanting to be sent and the recovery region consists of the packets that have been sent and the receiving region consists of the empty buffers which waits for the new packets. The lost packets present can be recovered from the recovery region and sender is notified by the receiver about the missing sequences.

* + 1. Receiver Signal Strength Indicator (RSSI)

In this research, the individual node considered for bacon transmission from source to destination is selected on the basis of RSSI value. RSSI defines the specific power level of the node being received by the antenna. If the RSSI level of the selected node is higher, than stronger radio signal energy can be observed at that node along with placement closer to that of destination node. In general, the radio components are deployed in WSNs to calculate the current RSSI value along with validation of whether the beacon received is valid or not. If the selected node RSSI value is within the range of threshold, then that node is selected for further transmission. If not within the range, then that path is rejected and further analysis is carried out to select the efficient and shortest path for transmission.

* 1. Data transmission through Improved RC-MAC protocol (IRC-MAC)

This process is similar to that of RC-MAC protocol whereas additional filtering process is deployed for secondary validation whether the selected node is efficient is transferring the data with minimum time and reduced data loss. At the initial stage, the selected node is evaluated in terms of Quality of Service (QoS) level with respect to predefined threshold value. If QoS is within the range of specified threshold limit, then it is processed through filtering process and RSSI value calculation. The limitation arise due to congestion avoidance, which frequently monitors the rate of flow of incoming and generated packets is minimized along with better communication rate amongst the buffer occupancy and choked packets. Furthermore, better results can be achieved in terms of packet loss rate and energy consumption compared to the existing RC-MAC protocol.

* 1. Data transmission through Intelligent Traffic and Resource Elastic Energy (Itree-MAC) protocol

This process is initiated with the construction of tree structure topology and the node attributes is selected on the basis of position. The relay component is selected by defining the set of target nodes, relay nodes and the directed edges respectively. Initially, undirected graph is constructed by selecting the direction of individual edge in E1 (Target node), then undirected spanning tree which is rooted with an arbitrary relay node is calculated along with all the set of target nodes. After the selection of the candidature nodes, evaluation is carried out in terms of predefined threshold value. If the selected target node and the path is within the threshold value limit, then it is processed through packet assumption stage, packet scheduling and processing to define whether the selected node is accepting the packet or rejecting on the basis of decision.

* 1. Software used

During the deployment of WSNs, several aspects such as rate of energy consumption, fault tolerance should be considered and the selected framework should provide better quality of service with high rate of synchronization and better support to scheduling strategies. It is seen that NS2 based software platform has better design capability tools and interface libraries for the target proposed system. The developed WSNs protocol is programmed as per the proposed design and implemented using NS2 platform. With the technological advancement and digitization, WSNs are used widely in many applications such as object protection and confidential data transmission, monitoring and intelligent guiding in military applications, in home intelligence and health monitoring applications. Furthermore, deployment of proposed protocol through NS2 framework has several advantages such as better scalability, effective communication through channel utilization, low power consumption with better fault tolerance capability, high assistance to QoS, Self-configurability with reduced design cost.