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To Analyze Energy Aware MAC Protocols for Wireless Sensor Networks

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ABSTRACT

Sensors are used in many fields to collect the information and send it to the central location; the role of energy conservation is more important in Media Access Protocol. This paper presents the limitation and description of MAC protocols with different techniques used in BMAC, LMAC, XMAC protocols and we implement BMAC, LMAC, XMAC protocol in Omnetpp5.5.1 simulator as per default configuration and values to run the protocols in omnetpp5.5.1 simulator and compare these three protocols as per energy parameters and find out the energy efficient MAC protocol. Our simulation result shows that the XMAC protocol is a more energy efficient, collision free protocol, the no of packets loss is also reduced in the XMAC protocol.

Key words: SBBU-SBA, MAC Protocols, Datalink Layer, Internet of Things.

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1. INTRODUCTION

Wireless sensor networks can be explained as group of dedicated sensors to monitor the physical or environmental conditions, collecting and recording the data at central device location [1]. WSN dealing with environmental conditions like temperature, pollution level, sound, vibration, pressure motions, humidity, and wind so on and send the information to the destination location. Sensors are equipped with various energy modules and computational limits [1] [20].
In sensor networks the life of the network is more important than other parameters the life of the network depend on the energy consumption and to optimize the energy is really a difficult and complicated task because in this situation we will reduce the energy but also increase the network life [1].
In sensor networks scheduling is more important to for proper flow of the node-to-node information. Many researchers proposed the fair scheduling mechanisms which are distributed as well as centralized schemes in direction to confirm the QoS criteria. Many schemes of scheduling are not working dynamics conditions [2].
To optimize the energy level of the sensors it depends on the environmental conditions, in some situations the optimization is more important than the network life and in some situations the optimization is not important because if sensors are deployed in the hospitals or emergency situations so the continuity of information is more important like heart patients etc., but in the forest or in open environment the energy is most important issue, we will optimize the energy level so that the network life should be increased (awake and sleep period of the sensors [3].

The wireless sensor networks introduce the new research activities in the field of energy consumption, data processing, singling etc. Presently many researchers are working on the energy design and their computationally aware algorithms and protocols. And the application must be focused on simple monitoring the data and applications [4].
Sensor's nodes are contained of four subsystems.

1. Computing system: microprocessor contain (MCU and microcontroller unit), this subsystem is responsible for implementation of protocols related to communication and sensors, MCU operates on different types of mode for management of powers and these modes operated on power consumptions so the modes should be energy aware also [5].
2. Communication system: in this subsystem nodes are communicating with its neighbors by using the radio of a sensor to save the energy and increase the life of the network we should turn off the radio completely rather than idle condition to save the energy [5].
3. Sensing System: it contain the sensors and actuators to link the nodes and outside world and energy can be reduced if performance will be optimize [5] .
4. Power system: it contains the battery, if sensors using the continuous power the life of the network is decreased so it is better to turn off the power of the

sensor time to time to save the energy and increase the life of the network [5].

Many authors worked on the optimization of energy and proposed different types of communications protocols, scheduling algorithms, hardware optimization techniques, to save the energy these protocols and mechanism should be energy efficient.

Media Access Control Protocols for Wireless Sensor Networks.

Wireless sensor networks MAC protocols are mainly categories into fours perspective cross layers, TDMA-based, contention-based MAC [6] the following MAC protocols are defined the sensors networks briefly [7]

- Sensor(S-MAC) [7], SIFT [7], Timeout-MAC, Dynamic-DSMAC [7], Traffic-Adaptive Protocol (TRAMA-MAC) [7], Wise W-MAC [7], IEEE 802.15.11 [8], Aloha, preamble sampling [8], Berkeley(B-MAC) [8], Power Aware Multi Access Signaling (PAMAS) [8], Optimization MAC [8], Data-Gathering (DMAC) [8], Self-organizing-MAC for Wireless Sensor Networks (SMACS) [8], TDMA Energy efficient MAC [8]

1.1 Issues in MAC-Layer

Many MAC issues of wireless sensor networks are discussed in [9]

1. **MAC protocol design** should be collision free, over emitting, over hearing packet control idle listening and overhead.
2. **Scalability**: the sensors nodes are increasing from two nodes to hundreds of thousands of networks the design of MAC protocol should be adapt the network changes from small to large also topology.
3. **Sensor network MAC protocol** have minimum latency rate to meet the high throughput whenever the it deployed in emergency application as well as critical.
4. **Sensors** are deployed randomly in larger area and may face the high collision or contention each other when they are sending the packets so the loss of the packet is also increased, in this situation MAC protocol should follow the uniform reporting mechanism.

In the sensor networks no one protocol is defined as the standard to follow in deployment scenario as many researchers proposed various MAC protocols for various types of application. In general, the mac protocol choice is on application dependent it means that no anyone standard we have to follow the sensor network. various issue are at physical layer define in [8] because of no any proper standardization.

1. TDMA decreases the throughput, traffic at low because of idle listening slots, and more difficult to shift within the decentralized environment in TDMA-traditional because all nodes are agreeing on same time durations slot or assignments.
2. In CSMA is used to handle the collision detection and collision avoidance methods to manage the collisions.
3. In additional FDMA requirement of circuitry involved and it increases sensors node cost that radio channels can work on dynamically.
4. In CDMA that consume high energy due the high computational requirements and it is major drawback in CDMA, and difficult to analyze the modulation schemes, waveforms, models of receiver and other problems of synchronization.
5. In S-MAC protocol the sensing duration is fixed that's why it consumes the more energy. [10]
6. For solving the fixe duration T-MAC has been proposed in T-MAC it consume less energy than others the nodes go to sleep early this mechanism increases the throughput and latency [10]
7. Data-gathering (DMAC) Media Access Control protocol uses the mechanism duty cycle of adaptive whereas DMAC out performs [11] in energy, throughput and latency, it supports the paradigm of communication and converge-cast. [12]

2. RELATED WORKS

1. [7] explained contention-based T-MAC protocol to reduce consumption of energy by active / sleep duty-cycle.
2. In this paper [12] author explained the energy aware, data-gathering (DMAC) and low latency protocol to improve tree data gathering in WSN, it resolves the problem of interruption by changing the status of scheduled active/sleep by using offset that subject to trees depth, also propose the prediction mechanism to solve the contention and collision.
3. In [3] present hybrid scheme of MAC, called Zebra-MAC for WSN to combine the CSMA and TDMA while off-setting weaknesses. It has both ability during the high and low contention, during the low contention in network it behaves as CSMA and in high contention it behaves as TDMA it has also dynamic topology.
4. [14] this author worked on the scheduling which based on the pattern of own traffic of neighbor's nodes rather than having fixed active/sleep wakeup period.

5. In [15] the author presents energy efficient (MAC) protocol for WSN on the shortened preamble approach, by using shorten preamble approach it consumes the low listening power called low communication power, simplicity and rejoin receiver sleep and transmitter schedules.
6. [16] Explained and proposed CSMA B-MAC for WSN that delivers a reliable interface to gain extreme low power operations and effectively manages the collision-avoidance and great utilization of channel. To complete small operation of power, B-MAC works an on the scheme that supports the adaptive sampling for preamble to little cycle and optimize idle-listening.
7. In [16] author proposed the CSMA MAC protocol to provide flexible, and less power operation to effectively manage the collision avoidance and give us room to utilize high channel. It uses the adaptive sampling scheme for preamble to lessen the duty cycle and reduce the idle listening
8. This paper [17] proposed TDMA based Protocol by changing neighbors' radio in mobile networks. In MLMAC it works dynamically to start synchronization because it does not depend on gateway.

3. MAC PROTOCOLS

Actually, the MAC protocol is divided into two categories when the node wants to communicate on the channel.

Time-Division-Multiple Access (TDMA): these types of protocols working on the time mechanism methods, specific time slot assigned to every node, during that time period they will wake up and communicate on the cannels to avoid the contentions. LMAC, TRAMA etc are the example of TDMA. Carrier Sense Multiple Access (CSMA): these protocols working on the carrier sensing mechanism to sense the carrier before sending the date or communication on the channel to avoid the backoff and collision

3.1 BMAC

Berkeley (BMAC) [18] is wireless MAC protocol used in wireless sensor networks. This protocol uses the sample scheme of adaptive preamble sampling scheme. This scheme contains of sampling medium at static intervals, it works on low-power listening (LPL) to minimize the consumption of power. Nodes have fixed intervals period in which sensors sense preamble medium for clear channel assessment (CCA), if detects preamble, nodes stay wakeup and wait for the data packet if none is detected, the node back to sleep state. If nodes send message, then it will first send preamble during the sleep period for all nodes to detect it. Note that the preamble does not contain the address information the address information contains in the data packet.

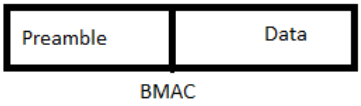

Figure 1: BMAC

3.2 XMAC

This protocol is extended version of BMAC, the standard BMAC protocol uses long preamble before data to wake up receiver, and this preamble scheme is enhanced version to lessen the energy power consumption. In BMAC the complete preamble is transmitted weather the node is awoke during the preamble from starting to end, in BMAC sensor nodes will receive complete packets preamble and data but in XMAC it sends the shorten preamble these shorten preamble is long enough to reach the destination and receiver receive the acknowledgement and it stop the preamble and send the data packets, this process will save the time and energy consumption instead of sending the whole preamble at once, the preamble contain the address of the node it receive and go back to sleep.

3.3 LMAC

This protocol is lightweight MAC the time frame is divided into the time slots. The time frame configures as per the no of nodes contain in the wireless sensor network. Each nodes have its own time period to transmit their data or communicate. These features save the power and also no collision or retransmission. A transmission contains the data unit and control message.

4. PERFORMANCE EVALUATION

4.1 SIMULATION SCENARIO AND PARAMETERS

To compare the MAC protocols BMAC, XMAC and LMAC we perform simulation in Omnetpp 5.5.1 the simulation contain 04 sensor nodes and gateway and one node is server. The nodes are deployed in warehouse, the size is 60*30 meters. Routers uses the star topology at center with gateway.

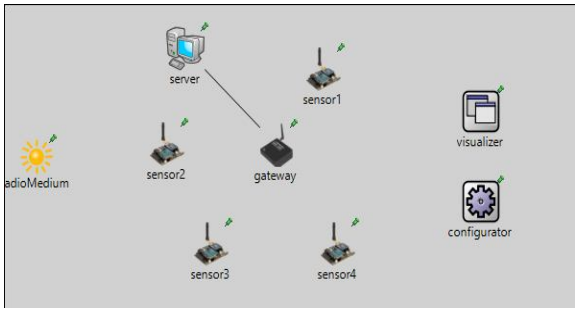

Figure 2: Omnet++ Simulation environment

Table 1: General configuration

Parameters	Values
Frequency (Radio)	2.45GHz
Bandwidth (Radio)	2.8MHz
Receiver sensitivity	-100dBm
Bitrate (Radio Transmitter)	19200bps
Header Length (Radio Transmitter)	8b
Preamble Duration (Radio Transmitter)	0.0001s
MAC: Header Length	8b
Receiver Energy Detection	-90dBm
Transmitter Power	2.24 mW
Radio: Snir Threshold Receiver	-8dB
Radio: Medium Background Noise Power	-110dBm

Table 2: BMAC Configuration

Parameters	Value
MAC Name	"BMac"
Slot Duration	0.025s
Simulation Time	100s

Table 3: XMAC Configuration

Parameters	Value
MAC Name	"XMac"
Slot Duration Gateway	0.1s
Slot Duration Mac	0.25s
Simulation Time	100s

Table 4: LMAC Configuration

Parameters	Value
MAC Name	"LMac"
Slot Duration	50ms
Simulation Time	100s

4.2 COMPARISON AS PER CONSUMPTION OF POWER

To compare the power consumption, we will find out the following parameters during the simulation.

1. No of Total Packet received at server because all nodes transmit the 100 packets during the 100-simulation time thus the total packets received 400 packets at the server host.
2. Power consumption of Network all nodes, the sum of 04 nodes and gateway values in joules.
3. Per Packet Power consumption, the total power consumption of networks divided by total no of pkt received.
4. Packet loss. In 100 simulation time all nodes send 100 packets means total 400 packets server will receive. The no of packet received divided by total packet sent.

5 RESULT DISCUSSIONS/ RESULT ANALYSIS

In this Figure 1 we have simulate three MAC protocol and run the simulation with 100s after simulation time we get these results, every node send 100 packets in sum 400 packets will be received at server side but in BMAC protocol only 136 Packets received while in LMAC 394 and XMAX receive 296 packets. So, the high no of packets received in XMAC and low packets received at BMAC.

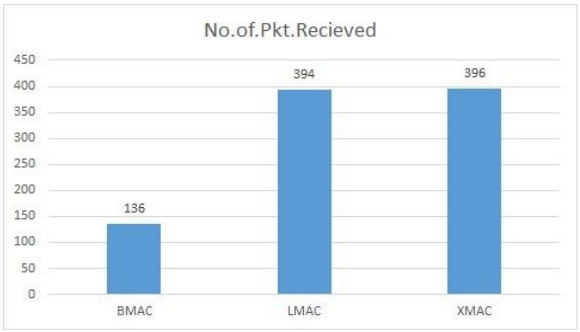

Figure 3: No of Packet Received

In this Figure 02 we simulate the power consumption of whole network and graph clearly shows that high power consumes at BMAC protocol and low power consume at XMAC protocol.

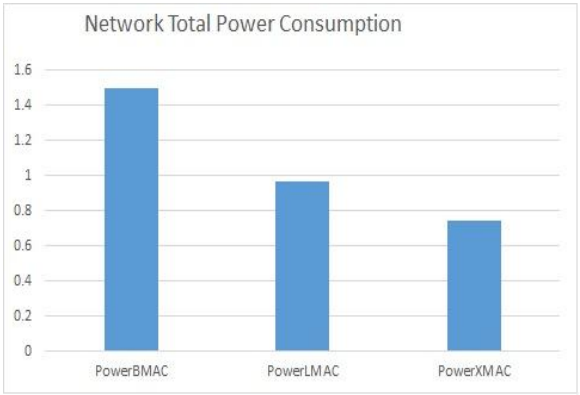

Figure 4: Network Power Consumption

In Figure 3 the simulation result it shows clearly that the no of packets loss in BMAC is high and no of packets loss in XMAC is low.

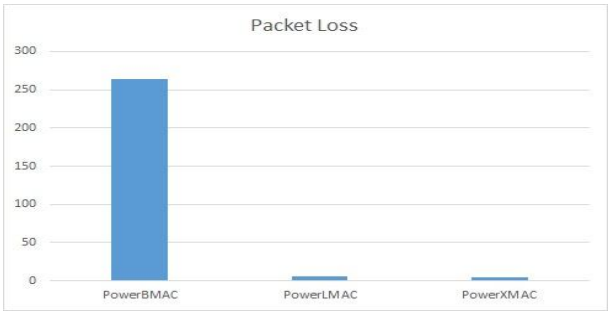

Figure 5: Packet Loss

In this Figure 4 the power consumption per packets, so the graphs clearly shows that the power consumption in BMAC protocol is high as compared to other two protocols and power consumption is low in XMAC protocol is low as compared to other two protocols.

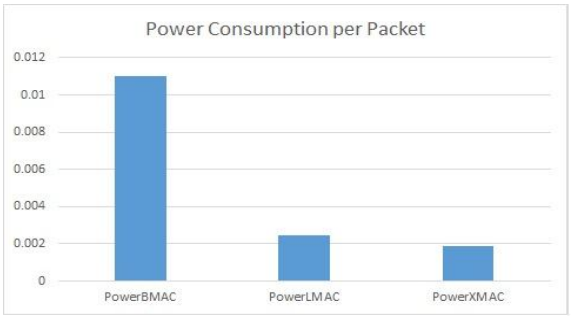

Figure 6: Power consumption Per Packet

In overall results shows that the XMAC and LMAC received high packets up to 98% while the BMAC receive the 35% Packets during the simulation of 100s. and BMAC consume more power as compare to LMAC and XMAC so significantly the XMAC consume less power. While the LMAC consume little bite more power than the XMAC protocol. So, the XMAC is power and energy efficient protocol as per the results.

6. CONCLUSION

In this paper we compared the power consumption of three protocol BMAC, XMAC and LMAC, we simulate and evaluate the results and power performance. Based on the simulation result we find out the XMAC is more energy efficient protocols as compared to BMAC and LMAC.

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