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Implementation of ITREE-MAC Protocol for Effective Power Management and Time Synchronization in Wireless Sensor Networks

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Abstract: *The advent of wireless sensor networks (WSN) has led in recent revolutionary modifications in electronic and communication systems .Various applications in wireless network needs time synchronization as a basic requirement. Wireless sensor nodes are tiny in size and operated at low energy to record the required physical parameters for low-duty apps. Because nodes have a tiny battery with a lower life span, power management is crucial for long-term working with the sensors. Wireless Sensor Network is a set of sensor nodes used to send and receive data packets from one sensor node to another. This work aims to propose three protocols such as Receiver Centric MAC protocol (RC-MAC), Improved Receiver Centric MAC protocol (IRC-MAC) and Intelligent Traffic and Resource Elastic Energy MAC protocol (ITREE-MAC) for the WSN environment and based on the application. These protocols help in studying the parametric measures such as delay, energy consumption, packet delivery ratio and throughput. The comparative analysis is carried out to select the more efficient protocol for the application of wireless sensor networks. This research work is implemented and simulated by using NS 2.35 Simulator. Based on the simulation results obtained for proposed protocols using the NS2 simulator. The performance of ITREE-MAC protocol shows better results for parameters end to end delay, energy consumption, throughput, packet delivery ratio. So the overall performance of ITREE-MAC protocol is much better than other three IEEE802.11 MAC, RC-MAC and IRC-MAC protocols. As per results obtained, energy consumption is less in ITREE-MAC protocol and save the power in wireless sensor network applications*

Keywords: *RC-MAC, IRC-MAC, ITREE-MAC, Energy Consumption, Time Synchronization.*

I. INTRODUCTION

The Wireless Sensor Network is a budding technology that contains an extremely huge number of small sensing devices, distributed over the physical space. Each device is able to radio communication, sensing and limited computing [01].

In many situations, the sensor network is compiled with gateways, Measurement Nodes (MN) and software. Spatially scattered MNs have various sensor nodes for gathering environmental data and then transfer them wirelessly.

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The central gateway, which may operate independently or linked to the host network, aggregates, processes and examines the estimated data [02]. A special kind of MNs can have extra functionality like routing to enhance the dependability and the scalability of WSNs. Software deals with the assignment of node resources in the controlled way. Operating systems can include special resources of WSN applications and include resource factors in the WSN hardware platforms. MNs contain four sub-systems such as sensing, power supply, radio communication and processing sub-systems [03].Figure 1 shows the general architecture diagram of WSN. Analog signal that found by sensors is digitized through analog-to-digital convertor (ADC) and then it is sent to processor for additional processing. Types of memory in sensor node contain RAM of external flash memory, micro controller and in-chip flash memory.

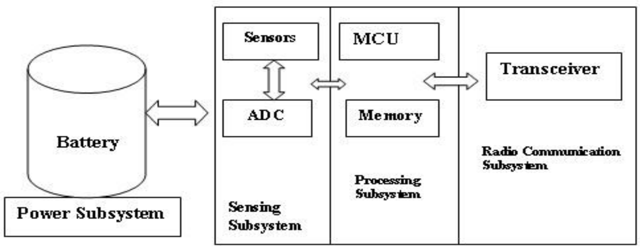

Fig. 1 General architecture of WSN

One of the most significant problems apart from routing and communication problems, software engineering guidelines, data management concerns and hardware constraints is energy or power optimization in WSNs. When compared to conventional ad-hoc networks, the most evident point regarding wireless sensor networks is in which they are restricted in computational capabilities, memory and power. Thus, optimizing the power consumption in WSNs has currently turned into the significant performance objective. In several application set-ups, replacement of power sources could be not possible. The power density of batteries has been doubled each and every 5 to 20 years based on the specific chemistry and extended fine-tuning of any chemistry productions that reducing returns. This reveals that power management will be the most serious matter in WSNs in future as it at the present.

Hence, power consumption may be separated into three significant domains like aggregation, sensing and communication [04]-[05].Though, batteries are considered as the major power supply sources for MNs in WSNs. The ideal features of typical WSN are as follows: scalability, remote configuration of MNs, less power usage, reliability, rapid data acquisition, loyalty of data flow over long-standing, with no maintenance or little, security and programmability. Expansion of network dynamics such as security, topology, routing depends on WSN is affected through power limitations of the sensor nodes. Reducing the overall power consumption in sensor network is considered to be more important challenge because of the complication of provided concern; it still remains as fertile research field [06]-[08].This research paper organized as follows: Start here with the associated job in Section II. Explain in Section III the configuration of simulation and the parameters used for simulation; clarify the outcomes and different graphs in Section IV. At the end, the paper is finalized in Section V.

II. RELATED WORK

Mo et. al., discussed that one of the excellent WSN properties is short range and reduced data rate wireless communications. For the reason that decreased quality wireless medium makes numerous issues on connections so new parameter interface quality is considered necessary. Two variables are used to adapt the demand using the efficiency of the connection. One is the average duration of transmission and the other is the average proportion of packet shipping. The average packet delivery ratio is the strength of the link and is evaluated by including unerringly obtained packet numbers among the complete packets sent over the pre-decided period of time. If the service percentage is higher, several packets can be correctly transmitted to adjacent nodes [09]. Li et. Al. indicated that brief and unstable wireless communication often resolves reliable communications. In order to create reliable communications, the retransmission scheme is used to retrieve the loss packets owing to the packet distribution proportion. For each packet, the average transmission time is referred to as how long it takes to fully transmit the packets on connection. More average transmission time means that some packets are waiting in a buffer for retransmission [10].Ceken explains that the communication scheme used to convey information between nodes is a major function block in each network of wireless sensors. Practical communication design is endorsed by the communication protocol stack consisting of application layer, datalink layer, physical layer, network layer and transportation layer where each layer is responsible for specific sub-systems. Each layer in the communication protocol stack has its own parameters that affect the power consumption in this layer. [11]. Stanley-Marbell et. al., stated that the conduct of the model of power consumption depends on its parameters. The parameters can be set when the design time when they can be considered as fixed resources or when a scheme is deployed. Common energy consumption parameters include power obtained, transmitted power, overhearing, collision, data connection frequency, sensing energy, overhead of MAC layer, overhead physical layer, transient power and sleeping power [12]. Ammer and Rabaey have indicated that the power obtained is the consumption of energy from one node to another to receive a information unit. Transmitted power is energy consumption when a information unit is transmitted from one node to another. [13]. Bouabdallah et. al. indicated that overhearing occurs when the node acquires packets sent to the shared medium and is not intended for it, whereas collision occurs when two nodes are simultaneously transferred. [14]. Cheng et. al., explains that link data rate is the average traffic flow from one node to another node whereas energy for sensing is the consumption of energy from sensing a bit [15]. Kohvakka , explained overhead of MAC layer is the overhead at medium access control layer which rely on the type of medium access control protocol whereas physical layer overhead is the bits of redundancy in packet at physical layer [16]. Liu et. al., elaborates that transient power is the wasted power when node alters its mode of operation whereas sleeping power is the wasted power when its node of sensor turns off entire units. Energy consumption in wireless sensor networks is very important as power consumption sources are restricted. Better understanding of sources of energy consumption in WSN is the answer for energy reduction [17].

III. METHODOLOGY

A. Intelligent Traffic and Resource Elastic Energy (ITREE-MAC) Protocol

In Wireless Sensor Networks (WSNs), the throughput is calculated in a predefined time window based on the total amount of packets received at the end of the target node.At the base station, the throughput value can be enhanced by increasing the size of the packet and at some particular point, there is a decrement in throughput due to load imbalance carrying capability. An advanced efficient protocol is needed to overcome the set limitations.

In this research, an efficient Intelligent Traffic and Resource Elastic Energy (ITREE-MAC) protocol is developed to enhance the performance of a communication system with dedicated routing with proper allocation of the resources. The work flow of the proposed system is as follows ,
The method of the proposed ITREE-MAC protocol is shown in figure 2.

The working is similar to IRC-MAC protocol, but additional tree is developed to ascertain the size of the packet. Steps involved to implement the proposed system is as follows,
Step 1: A beacon message is transferred by the individual node for obtaining the status of the node. Status of the individual node defines the node case whether it is in a sleep state or wake up state (nid). The term ‘nid’ defines the neighbour id of the node.
Step 2: RTS/CTS flag is set before and after getting the status of the channel.
Step 3: Individual frames has been structured on the basis of bandwidth and the slot time TX.

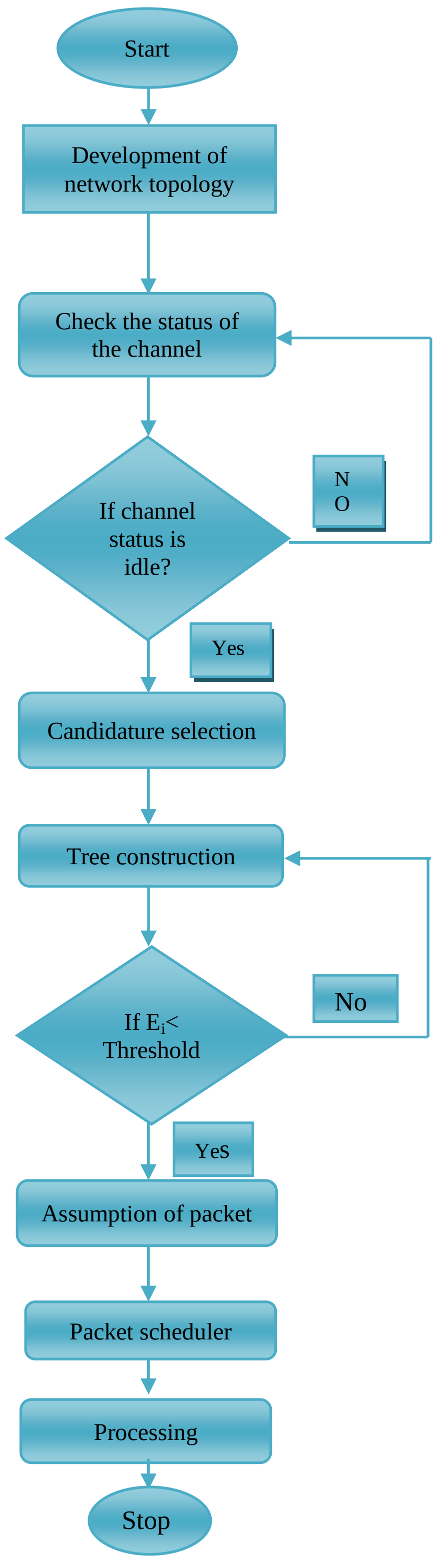

Figure 2 Flowchart of ITREE-MAC Protocol

Step 4: You can obtain the maximum permitted queue process from individual transmission slots at T sec moment. T sec describes the delivery time in seconds.

Step 5: T_r defines the delay unit obtained from the propagation variance when the transmitter receiver is at the distance r_x.

'T_r' = Rate of transmission

'r_x' = Rate of reception

Step 6: The probability of the delivered node with respect to an new entity is defined through the access slots 'n_b'; where n_b defines the neighboring slots

Step 7: In later stages, and efficient Itree_MAC protocol is employed in which the time consumption is divided into three different slots. Individual node assigns its frames on the basis of packet size. The equation for the same is given by,

$DF = nid(Packet\_size)$- (1)

Number of nodes has been assigned on the basis of network requirements.

Step 8: A routing tree is developed on the basis of network id limit values. Status information of the intermediate nodes is updated for every first and second cycle in the co-operative transmission.

Step 9: The data packets for the transmission is generated by the source node on the basis of interval time. Further, source node evaluates the neighboring node on the basis of several critical energy parameters. Individual frame is aligned and adjusted as per the timer in MAC protocol.

Step 10: This data is processed through the noise interference level to estimate the level of distortion during WSNs.

Step 11: Individual node should satisfy the condition of quality of service level within the network before it is processed through the network. During this process, data aggregation takes place amongst the neighboring node and co-operate transmission. Packet balancer is employed for classification of the node on the basis of load fluctuations such as heavy, medium and low categories and certain threshold will be set for packet transmission through load level.

The algorithm is developed on the basis of above mentioned steps and is processed through the NS2 platform for further evaluation and calculating the critical parameters.

The Implementation of ITREE-MAC protocol as follows:

To create transmission between neighbor nodes.

1. $\boldsymbol{f(x)} =$ $[\boldsymbol{n_1(x), n_2(x), n(x), \ldots, n(x)}]^{\boldsymbol{T}}$=E=$[\boldsymbol{E_1, E2, E_3, \ldots, En}]^{\boldsymbol{T}}$

E(i)-> Initial energy level of the node

Receiver node shows that average one hop delay is high, selecting the shortest path.

Energy level is not impacted beyond a defined helper time timetable.

First and second cycles involve a cooperative transmission and nodes update their status data to intermediate nodes.

Then it enters the planning of the channel to assign communication to the channel.

2. Nbr_id = Eres(i)+E(ie)

Eres(i),E(ie) be two vectors for space entry of hops.

Eres(i)->Residual energy of the node

E(ie)->Ideal energy of the node

src dominates route, only when, $Ei_i \leq$ Th(i)

i=1, 2,…, k

The receiver node is greater than the transmitter node and cooperative transmission is implemented .

Received signal strength indicator.

3. $\boldsymbol{RSSI = 10[n(log10 * dist) + ip\_(i)}$

Ip_(i)-> ideal power

4. CPF=1/alpha(Ei)+beta(time)* δs,r + Es,r [ni]*weight;

CPF(Combined performance function)

Analyze the amount of signal interference estimated. Adjusted each frame according to the amount of slots for access. If it reaches a restricted limit, a period has been processed.

5. $\boldsymbol{(t+1) = X(t) + V_i(t+1)}$

$$\mathbf{6.}\ fi(t+1) = f_i(t) + c_1 r_i 1(t) \times \left(p_{besti}(t) - x_i(t)\right) + c_2 r_i, 2(t) \times \left(g_{powerbest}(t) - y_i(t)\right)$$

Li $=\sum_{nn} Pi(qos)$

Pi -> Priority.

Qos-> quality of service

Li -> Load of node

7.Load_(i)

$$=\frac{1}{T}\sum_{t=1}^{T}\sqrt{(f(t)-f(t-1))^2+(fi(t)-fi(t-1))^2}$$

Node qos level should be compare with the packet size.

If the node fails the QOS level the particular node should be rejected from the transmission.

Packets are allocated to the point of priority.

Transmission of the packet starts with avoidance of congestion.

Data aggregated by the neighbor node and cooperate transmission takes place.

D(x) ,D(y) be the aggregated data by the different source node S.

if Dist(nid) > D(xi),

then rl(i) is the Loaded path.

8. T1= Eelec+Eth1/Em if di < dsink

9. T2= Eelec+Eth1/Em if di > dsink

10 T3= Eelec+Eth1/Em if di = dsink

Eelec->Elected node

Eth1-> Energy threshold

di-> distance of the current node

Dsink-> distance of the sink

Calculate the residual energy (Eres)

11. Eres = Etrans – Erec.

Eres - Residual energy of each node.

Etrans - Power consumed by the transmitter node.

Erec- Power consumed by the receiver node.

Packet balancers classify the node based upon the load.

Highly-loaded, When Lche > $L_{threshold}$.

Data Processing:

msg1=node1_addr%n(1)*msg(i);

Optimal_msg:

12. Prob_msg=1/k-1{mi+1}

13. Prob_msg=(1-mi)*(1-mi/1-fi)

Store and update the message from msg1 to msg(n)

Medium-loaded, When Li < $L_{threshold}$.

$L_{threshold}$ is predefined value else normal.

Then the load is to be categorized as heavy, medium, low Packet transmission should be varied based upon the load level.

IV. RESULTS AND DISCUSSION

In order to enhance the throughput of the WSNs system along with the packet deliver ratio and end to end delay, an energy efficient ITREE-MAC protocol is developed and implemented using NS2 simulator. For the analysis report, performance parameters such as end-to-end delay, energy consumption, packet delivery ratio and throughput are considered and the results are compared with the protocols IEEE 802.11MAC, RC-MAC and IRC-MAC. AODV-based protocol and packet size of 780 bytes are considered during implementation and the total number of sensor nodes is 100.

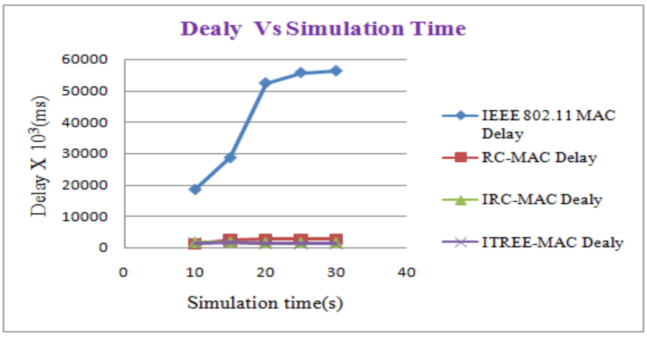

Fig. 3 Delay comparative analysis of four protocols

The IEEE 802.11 MAC, RC-MAC, IRC-MAC and ITREE-MAC protocol comparison assessment is shown in Figure 3 regarding end-to-end delay. It is noted that compared to all other protocols, IEEE 802.11 MAC protocol has more delay. There is less delay in RC-MAC and IRC-MAC protocols compared to IEEE 802.11 MAC protocol. Finally, ITREE-MAC protocol has much less delay and is 97.48% less with IEEE 802.11 MAC protocol, 48.14% less with RC-MAC protocol, and 6.83% less with IRC-MAC protocol.

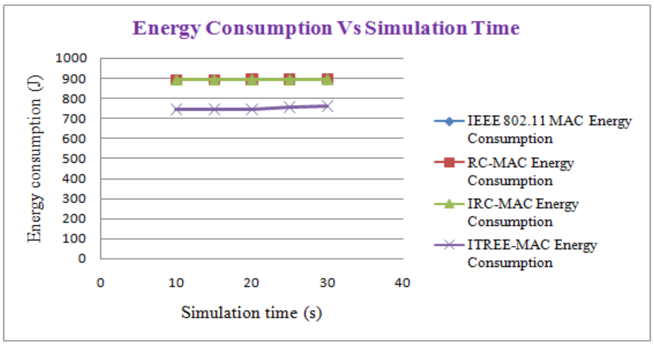

Fig. 4 Energy consumption comparative analysis of four protocols

The comparative analysis of IEEE 802.11 MAC, RC-MAC, IRC-MAC and ITREE-MAC protocol is with respect to energy consumption is shown in figure 4. It is observed that IEEE 802.11 MAC, RC-MAC, IRC-MAC have more energy consumption compare to other protocol. Finally ITREE-MAC have less energy consumption and it is 16.40% less with IEEE 802.11 MAC protocol, 16.31% less with RC-MAC protocol and 16.29% less with IRC-MAC protocol.

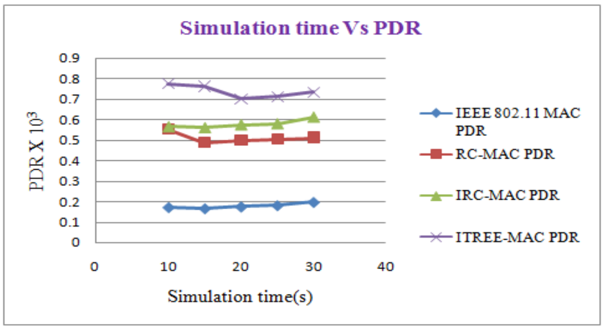

Fig.5 Packet delivery ratio comparative analysis of four protocols

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The comparative analysis of IEEE 802.11 MAC, RC-MAC, IRC-MAC and ITREE-MAC protocol is with respect to packet delivery ratio is shown in figure 5. It is observed that IEEE 802.11 MAC, RC-MAC, IRC-MAC have less packet delivery ratio compare to ITREE -MAC protocol. Finally ITREE-MAC have more packet delivery ratio and it is improved by 74.96 % with IEEE 802.11 MAC protocol, improved by 29.01 % with RC-MAC and improved by 18.20% with IRC-MAC protocol.

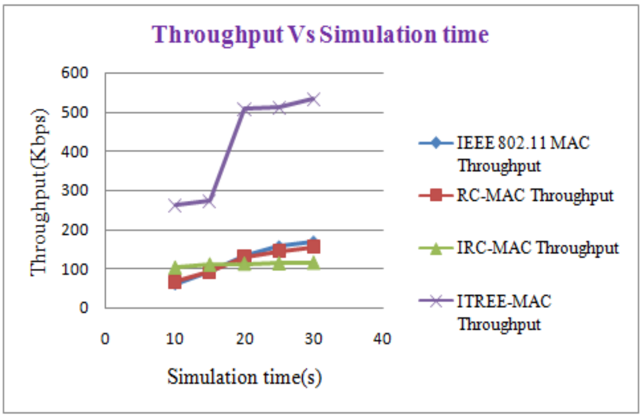

Fig. 6 Throughput comparative analysis of four protocols

The comparative analysis of IEEE 802.11 MAC, RC-MAC, IRC-MAC and ITREE-MAC protocol is with respect to throughput is shown in figure 6. It is observed that IEEE 802.11 MAC, RC-MAC and IRC-MAC have less throughput. Finally ITREE-MAC has more throughput compared to other protocols. ITREE-MAC has throughput improved by 69.63% with IEEE 802.11 MAC, it is improved by 77.5% with RC-MAC protocol and it is improved by 77.62% with IRC–MAC protocol.

V. CONCLUSION

In this research work, the four efficient protocols comprising IEEE 802.11 MAC, RC-MAC, IRC MAC and ITREE-MAC are designed, developed and implemented to analyze their behavior as real time scenario. It is aimed to incorporate the innovative ideas into proposed protocols analyzed and compared their performance measures. During the evaluation, parameters such as end-to-end delay, energy consumption, packet delivery ratio and throughput are regarded and the findings are contrasted with current protocols. These protocols are individually evaluated in terms of parameters and made comparative analysis and identifying the outstanding performance protocol. It is observed that the proposed ITREE-MAC Compared to other protocols, the protocol offers better outcomes.The performance of ITREE-MAC protocol is much better than IRC-MAC protocol and also better than the rest of the two protocols for the measurement of end to end delay. The end to end delay improved by 95.84% in ITREE-MAC protocol. The energy consumption parameter is improved by 15.97%, and the packet delivery ratio is 75.63 percent higher than the other three protocols. The throughput is also improved by 77.82% compared to other three protocols.

VI. ACKNOWLEDGMENT

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