

Analyzing Performance of Adaptive Duty Cycle Scheduling Algorithm and Attribute Based Efficient Data Delivery for Code Dissemination in Multihop Wireless Sensor Network.

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Abstract— In this paper, we have analyzed the performances of two designed algorithms which are an integral part of our research to formulate more energy efficient Code Dissemination Protocol for Multihop Wireless Sensor Network to provide the facility of reprogramming in order to support energy efficient over-the-air software updates in sensor, to set new functionalities or features, patch errors in the software after deployment & to set some parameters as per new requirements. It enables the sensor nodes to self-reprogram so that they can adapt to changing tasks and evolving environments. In this research we have tried to address the energy optimization issue. The objective behind designing the Adaptive Duty Cycle Scheduling Algorithm is to minimize energy consumption & reduce end-to-end delay for variable traffic load in the network and the objective to design the Attribute Based Efficient Data Delivery with Selective Approach is differentiated message delivery to achieve data reliability through the attribute based data flooding in multihop WSN & Sleep schedule techniques to minimize energy consumption through node selection.

Keywords— Attribute based programming, Duty cycle, MAC, Multihop Wireless Sensor Networks.

General Terms: End-to-end delay, Energy Consumption, Reliability.

I. INTRODUCTION

Energy is the most critical issue in wireless sensor network. Packet collision, overhead, overhearing, over emitting & idle listening are the causes of energy wastes. In order to minimize the energy consumption; several protocols have been developed. Using a fixed duty cycle causes unnecessary energy wastage because even if there is no transmission; it has to be an active state, leading to the problem of idle listening which in turn causes ineffective control over variable traffic load. Adaptive duty cycle scheduling algorithm is suitable for variable traffic load in the network. It's

aim is to decrease energy consumption by using sleep schedule technique. The proposed algorithm performs better in terms of energy efficiency and reduced delay. The algorithm is designed for both scenarios i.e., low and high traffic & tries to improve network lifetime and energy efficiency. The other issue which has been considered is the reliable data transport with minimum energy consumption. This is an important factor for dependability and quality of service in several applications of wireless sensor networks[6]. Different applications have different reliability requirements, for example an application to collect environmental parameters like temperature and humidity etc. periodically can ignore an occasional loss of a value from a particular sensor but for an application in which the data collected by every sensor is a critical piece of information, end-to-end reliability has to be guaranteed for every individual packet. Data aggregation plays an important role in energy conservation of sensor networks. The Attribute Based Efficient Data Delivery with Selective Approach algorithm aims at a differentiated message delivery to achieve data reliability through an attribute based data flooding in multihop WSN.

This paper is structured as follows.

Section I deals with introduction on Network Creation & Clustering Model.

Section II presents the design of proposed Adaptive Duty Cycle Algorithm.

Section III presents the design of Attribute Based

Efficient Data Delivery with Selective Approach algorithm.

Section IV analyzes the performance of the Proposed Algorithm, followed by acknowledgement & Conclusion.

I. NETWORK CREATION & CLUSTERING MODEL

A. **Network Creation:** The simulation area considered is 500mx500m. The sensor nodes are deployed randomly and increased from 20 to 200. Every node has a unique ID. The transmission radius for each node is 250 m. The nodes are capable of communicating only if they are in transmission range of each other. Each node randomly generates a packet and sends it to the sink over multiple hops. The protocol used for communication is Adhoc on demand distance vector routing [4]. In AODV, RREQ message is broadcast by the node who wants to communicate. The RREQ consists of src_addr, src_seq_no, broadcast_id, dest_addr, dest_seq_no & hop_cnt. The algorithm works as follows.

Begin

At source

If a route to the destination exists

Send data

Else create a RREQ packet

Increment the RREQID by 1

Increment the sequence number& hop count by 1

End If

At intermediate node

If a fresh route exists

Generate RREP

Else if stale route exists

Change seq_no of destination node

Increment the hop count by 1 and forward

End if

At destination

Increment seq_no of the destination

Generate a RREP message and send back to the source

Starts communication

End

B. **Clustering Model:** Clustering is used to make the routing energy efficient. Due to clustering, the energy is balanced in all the nodes in the network. The highest energy node takes the responsibility of acting as a head of the group which not only removes the redundancy but also removes unwanted data. The network is divided into numerous clusters, where each cluster is

controlled by a cluster head (CH). Broadcast messages sent by the cluster head are received properly within a fixed time by all of its 1-hop cluster members. It requires only active nodes to recognize its 1-hop neighbors. Nodes periodically sense the network and then send out data to their cluster heads, which transmit the collected data to the base station (BS).

Algorithm.

Begin

Set threshold energy value to 50J

Form a group of more than 3 nodes but they should be in Tx range of each other.

If node energy > threshold energy

Return highest energy node as CH

Else become CM

Return next highest energy node as next CH

If node energy < threshold energy

Switch CH

Update info table

End

C. **Simulation Setup:** The simulation is performed using .net to evaluate the performance of the proposed algorithm. The simulation area considered is: 500x500m². The values of the simulation parameters are also listed in Table 1. A node can act both as sender as well as a receiver. The simulation is executed several times to analyze the performance by varying the number of nodes per iteration.

TABLE 1. SIMULATION PARAMETERS

Sr. No.	Parameters	Values
1	No. of nodes	Max 200
2	Initial energy	100J
3	Transmission range	250m
4	Simulation area	500m*500m
5	Duration of simulation	100s
6	Sleep/active time	10ms
7	Packet size	512byte
8	Routing protocol	AODV

II. ADAPTIVE DUTY CYCLE ALGORITHM

The objective to design an algorithm is to improve performance in terms of Minimum energy consumption & reduced end-to-end delay which is suitable for variable traffic load in the network .In proposed algorithm, the active time of node is changed when there are too many packets in the network. When the number of nodes is less, the randomly generated packets are also less but for a larger number of nodes,

more packets are generated . If the traffic load is low, the code is executed on the cluster head. The cluster head broadcasts a hello to all its member nodes. The control message contains the source address and the next wake up time so that the member node and the cluster head are able to communicate at the same time. Only the nodes having packets in their buffer can respond to the cluster head at the time mentioned in the control message. The cluster head after collecting data from its respective members can forward the same to the other clusters. The hop-to-hop communication takes place using AODV routing protocol. At times it may happen that after sending the hello, the cluster head changes its role due to energy depletion. In such a case the member nodes communicate with the new cluster head by identifying the new id and delete the old one. The algorithm is given below:

A. Function Code for duty cycle

```
Public Function DutyCycleGnrate() As String
Public Interval As Double = 10.0
Public DutyCy As Double = 0.003
If NodeList(i).Node_Status = True Then
Tss.NodeStatus = "WAKE"
Else
Tss.NodeStatus = "SLEEP"
End If
If DutyCycle.Next (0, 10) < 5 Then
Return "DutyCycle_Min"
Else
Return ("DutyCycle_Max")
End If
End Function
```

B. Performance Metrics

The performance of algorithms is assessed with respect to the fundamental metrics i.e. Energy consumption & End-to-end delay [7]:

i. **Energy Consumption** - It is the energy spent by a node on an average during simulation, divided by the duration of the simulation and expressed in Joule. The figure 1_ shows the no. of nodes versus average residual energy. The initial energy is 100J, so the energy consumption can be simply found out by deducting the residual energy from initial energy. The X-axis indicates the No. of nodes and the Y-axis indicates the average energy consumption in joules. The formulae are given below.

Energy consumption = $E_{tx} + E_{rx} + E_{active}$
Where,

- E_{tx} is energy required for transmitting the data
- E_{rx} is energy required for receiving the data
- E_{active} is the energy required till the node is active .

Hence, the average residual energy is calculated by,

- Average residual energy = 100 – Energy Consumption

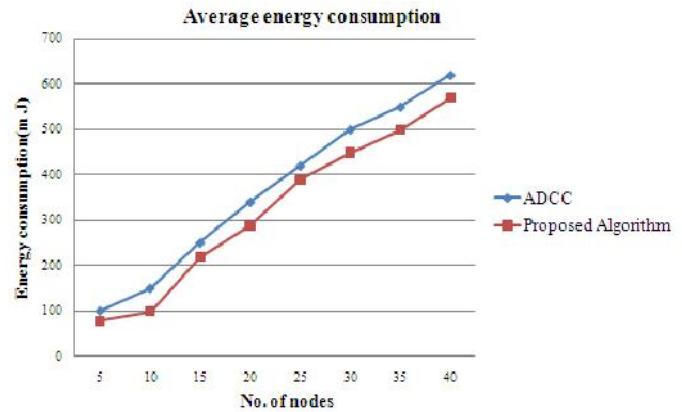


Figure 1: No. of nodes Vs Energy consumed

Figure 2 shows the residual energy versus the node id. The performance is evaluated by executing it several times over different number of nodes.

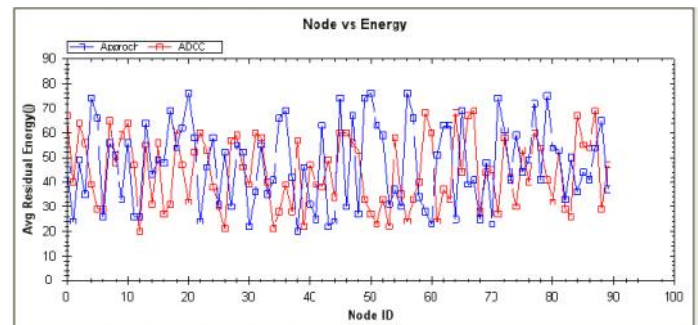


Figure 2: Node ID Vs Avg. residual energy

ii. **End-to-end delay**- It is the total time taken for the packet to reach from source to destination and measured in seconds. Figure 3 shows the performance of delay in seconds. The X-axis represents simulation time and Y-axis represents the delay. It is observed that the delay factor is reduced by 2%.

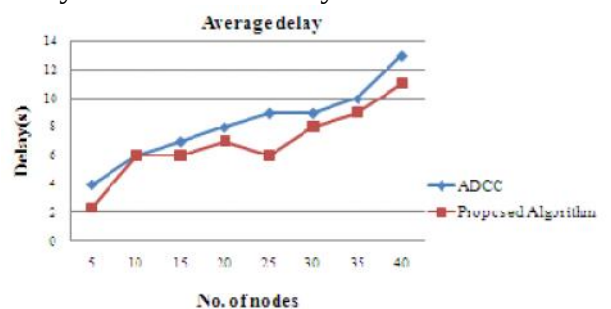


Figure 3: No. of nodes Vs Delay

Figure 4 shows the delay performance between proposed algorithm and the ADCC approach in milliseconds. The trace file generated after executing simulation which saved the energy consumption by the source and destination at a particular time and instant, is saved. It also contains the state of the nodes after the simulation is started.

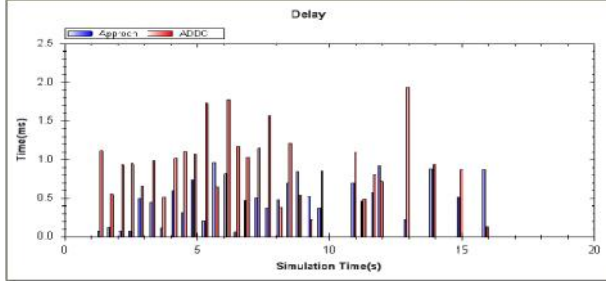


Figure 4 : Delay performance in Simulation time Vs delay (ms)

III. ATTRIBUTE BASED EFFICIENT DATA DELIVERY WITH SELECTIVE APPROACH

The objective to design an algorithm is differentiated message delivery to achieve data reliability through an attribute based data flooding in multihop WSN & apply Sleep schedule technique to minimize energy consumption through node selection. Data aggregation among different nodes is on the basis of set attributes like min or max temperature & sensitivity etc. This data is collected in three different modes i.e time-query-event and according to set attributes and applications. In time based mode data is collected through hop by hop method. For this algorithm is given as follows.

A. Algorithm

```

Time based
If (Present value-old value>sensitivity)
Then
    Initialize-node()
    Report(data1,self-id+1)
    Next node
    Report(data,data1,self-id+1)
    Send ack
Else
    Report (null, null, null)
Query mode:
If Q(q,node-no)
Then report (id-present value)
Event mode:
If(Temp>Max Temp or Temp<min Temp)
then (Alert window occurs)

```

B. Function Code

```

Main Block
while(1)
{
    get_ad(0x00);
    data1 = ad_voltage/2;
    if((data1 - old_val) > sensitivity);
    {
        if (write_l_buffer() == FALSE)
        {
            if (write_l2_buffer() == FALSE)
            {write_tx_buffer();}
            if (data1 > upper || data1 < lower)
            {write_tx_buffer();}
            old_val = data1;
            _delay_ms(1000);
        }
    }
    if (data1 > upper || data1 < lower)
    {write_tx_buffer();}
}

```

```

char write_l_buffer()
{spi_write(TXFIFO+0x40);
 delay_us(10);
 if (self_id + 1 < 4)
 {
     spi_write(self_id+1);
 }
 else
 {
     spi_write(1);
 }
 delay_us(10);
 spi_write('T');
 delay_us(10);
 spi_write(data1);
 delay_us(10);
 spi_write(NULL);
 delay_us(10);
 spi_write(NULL);
 delay_us(10);
 spi_write('D');
}

```

C. Evaluation Metrics

Given below are a few terms through which we are going to evaluate the performance of LEACH routing protocol.

i. Network Throughput :

This is the ratio of total number of packets received successfully by the destination nodes to the number of packets sent by the source nodes.

Network throughput = Number of packets received by the destination/Number of packets sent by the source

ii. Average end-to-end Delay:

It is the total time taken for the packet to reach from source to destination measured in seconds.

iii. Error messages are calculated on the basis of errors that occur in a thousand messages.

iv. Reliability is calculated by heating temperature sensor to this test

D. Performance metrics

i. Energy consumption:

It is the power required by a node to transmit data to the receiver node. Here power consumption is calculated on the basis of the mode of transmission.

In the event mode and the query mode, power required to transmit is more because it directly transmits the data to the sink without transmitting hop by hop. The voltage required is considered as 3.3v and current required in event and query mode is 21.2mA.

Power required at event and query mode is

$$\begin{aligned} P &= VI \\ &= 3.3 \times 21.2 \\ &= 70 \times 10^{-3} \text{ watt} = 70 \text{ mW} \end{aligned}$$

Power required in Time = $3.3 \times 11.1 = 37 \times 10^{-3}$ watt = 37mW

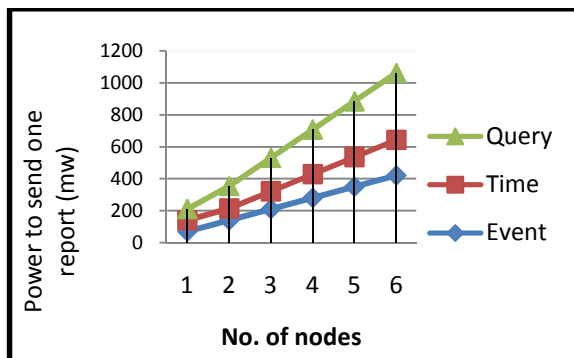


Figure 5 : Energy efficiency

No. of Node	Power consumed		
	Event	Time	Query
1	70	70	70
2	140	140	140
3	210	210	210
4	280	280	280
5	350	350	350
6	420	420	420

Table 2: No. of Node Vs Power consumed

Calculation:

$$\begin{aligned} P(\text{Event}) &= VI \\ &= 3.3 \times 21.2 \\ &= 70 \times 10^{-3} \text{ watt} \\ P(\text{Time}) &= 3.3 \times 11.1 = 37 \times 10^{-3} \text{ watt} \\ N1-N2 &= 37 \times 2 = 70 \text{ mw} \\ P(\text{Query}) &= 70 \text{ mw} \end{aligned}$$

ii. Data transmission: In event and query mode transmission from node to base station transmitted bytes are fixed i.e. $4 \times 8 = 32$ bits. In multihop mode if all nodes send data then the packet contains insertion and forwarding request, data i.e. 2 bytes from the first node to second, 4 bytes from second to third and 12 bytes from third to the base station. The time required to send one report is given as follows.

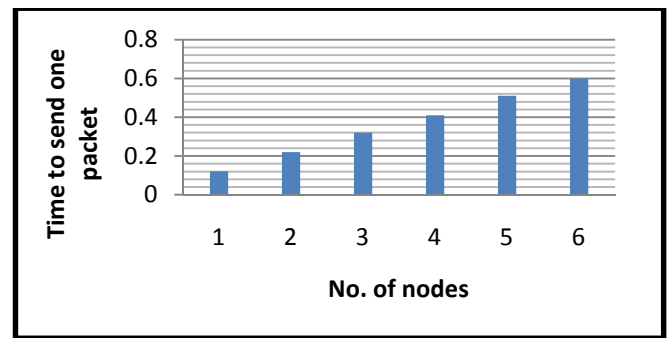


Figure 6: Time required for transmission

$$\text{Data rate} = \frac{(256 + \text{DRATE} - M)2^{\text{DRATE} - E} \times f_{\text{xosc}}}{2^{28}}$$

$$= 250 \text{ kbps}$$

Assume $M=59$ and $E=13$: Time to transmit = Bit/speed

$$= 32/250$$

$$= 0.124 \text{ s}$$

Fig 7: shows the number of error messages that occurred in the transmission of messages through different schemes. X-axis shows the number of messages and y-axis shows the number of error message. It is observed that the error factor came down by 1%.

iii. Comparative Analysis

Error message occurred	Amount of messages			
	LEACH	CRDD	DSR	Proposed
100	9	3	8	2
200	17	5	15	3
300	25	6	23	5
400	34	8	33	7
500	50	9	40	8

Table 3 : Tabular representation Amount of error message occurred

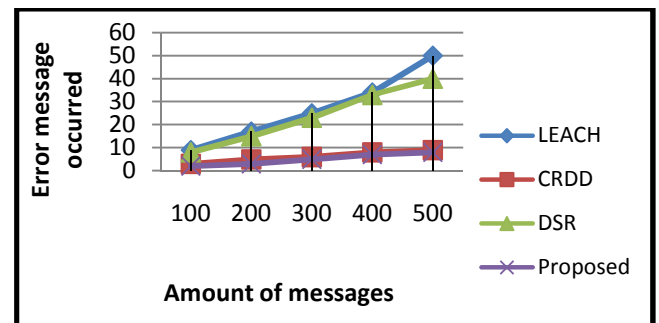


Figure 7: Amount of error message occurred

Figure 8 shows the reliability and delay graph of different schemes. It is observed that reliability has improved by 3% and delay is cut down by 0.1 s.

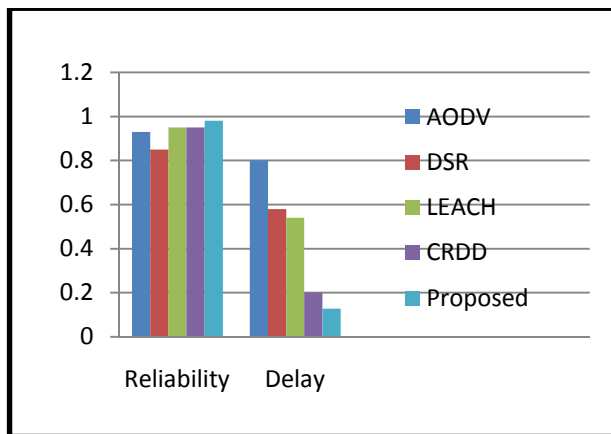


Figure 8: Graph representation of reliability and delay

	CRDD	LEACH	DSR	AODV	Proposed
Error	0.03	0.85	0.9	0.9	0.02
Reliability	95%	95%	93%	85%	98%
Delay	0.2s	0.54s	0.579s	0.801s	0.128s

Table 4: Tabular representation of reliability and delay

IV. PERFORMANCE & ANALYSIS

The main aim of this paper is to focus on two different algorithms designed by us & their analysis by taking into consideration the main key issues of WSN like energy optimization, end-to-end delay & data reliability through an attribute based data flooding in multihop WSN.

From the performance evaluation of algorithm, it has been analyzed that initially the delay is lower than ADCC and almost the same for 10 nodes and as the number of nodes increases, the difference starts increasing gradually. The proposed algorithm preserves a fine level of performance by achieving the end-to-end delay guarantee, data reliability and energy efficiency, even in variable network conditions. It also shows the compatibility among different nodes in heterogeneous environment. It can take 200 nodes as maximum limit so the analysis can be extended to pick up the performance by taking more number of nodes into account.

V. CONCLUSION

It shows that, an increase in energy efficiency by 12% & reduction in the delay factor by 2% as compared to ADCC. It also shows the compatibility among different nodes in a heterogeneous environment. It elucidates that reliable transmission takes place in almost 98% of the cases as compared to the previous techniques like CRDD, DSR etc.

There are still a few key issues & open problems that need further investigation to make reprogramming highly usable and efficient. From the analysis of these schemes we can conclude that these methods will be helpful for designing adaptive reprogramming in Wireless Sensor Networks.

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Our research work is in progress to design & implement a real time reprogramming architecture for Wireless Sensor Networks in which the algorithms discussed in this paper will play an important role to design more robust solution for WSNs. The research work in this paper was supported by G. H. Raisoni College of Engineering, Nagpur. Dr.L.G.Malik is the corresponding supportive author.

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