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Least Power Adaptive Hierarchy Cluster Framework for Wireless Sensor Network using Frequency Division Multiplexing Channelization

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Abstract

Background/Objectives: To develop a Least-Power Adaptive Hierarchy Cluster (LPAHC) framework which combines the energy-efficient cluster-based routing and improve network lifetime based on Channel State Information (CSI). **Methods/Statistical analysis:** initially, the LPAHC framework obtained the CSI using the Frequency Division Multiplexing (FDM-based) Channelization technique. The FDM-based Channelization technique is applied with the objective of reducing the average energy cost adopts frequency bands to assign channel for each sensor nodes based on the traffic patterns. Then, based on the frequency bands assigned, the selection of cluster head is made by applying Adaptive Hierarchy Cluster with aiming at improving the network lifetime. Finally, communication between sensor nodes is made in an effective manner using Received Signal Indicator (RSI) from the cluster head. **Findings:** The experimental evaluation of energy efficient framework using LPAHC in WSN is measured in terms of density of sensors, energy consumption, network lifetime average energy cost and average delay time consumption. **Application/Improvements:** Compared to the tradition energy efficient frameworks in WSN, LPAHC framework is able to reduce the energy consumption for data communication between sensor nodes and reduce the average energy cost.

Keywords: Communication Protocols, Channelization, Channel State Information, Hierarchy Cluster, Received Signal Indicator

1. Introduction

The cluster based routing method has been the most popular routing methods in WSN as it provides simpler means for data communication between sensor nodes in the network. Discrete rate adaptation mechanisms[1] were developed for improving the system throughput. Another author proposed a Fair Maximization of Energy Efficiency called, FMEE[2] to maximize the energy efficiency using game theory method. These methods focus on energy efficiency of routing in WSN.

Signal splitting scheme[3] was designed in order to improve the energy efficiency of the sensor nodes during data communication in WSN. To solve the problem of coverage constraints, author introduced a minimization framework[4] for network energy consumption in both types of networks called, homogeneous and heterogeneous networks. However, OMBS demands a more general fading mechanism to reduce the average delay time. Another efficient algorithm[5] was illustrated for effective identification of neighbor sensor nodes in order to improve the delay time. In wireless sensor networks, the author proposed a new clustering algorithm[6] for cluster head selection. However, in this work, the amount of overlap between sensor nodes was high which increased the average energy cost.

Message forwarding schemes[7] was introducing by using stochastic tools to improve the overall network

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performance. A radix-based approach[8] used hybrid modulation scheme to improve the network lifetime. However, the energy efficient scheme using hybrid system did not reduce delay time. Another optimization method[9] was presented using flocking algorithm and Particle Swarm Optimizer. Though energy optimization was achieved but at the cost of energy. Mobile Sink Assisted algorithm[10] (MSA) was designed to maintained the lifetime of the network. However, optimal path for movement of sink was not efficiently handled.

Hop-based energy efficient algorithm has also been extensively studied in the literature. Representatively, many authors proposed a hop based cluster routing[11–14] in wireless sensor network to reduce transmission load and improve network lifetime and throughput. However, these methods also do not consider how to reduce the latency. Particle swarm optimization algorithm[15] was designed to improve the energy efficiency of the network and to improve the overall quality of service.

In order to improve the packet delivery ratio, the importance of routing algorithms must be determined which system called as an intelligent routing protocol[16]. However, this study did not deal with factors related to network design. A scalable multipath routing protocol[17] was introduced in WSN with the objective of improving the packet delivery ratio. However, it cannot be applied to dynamic scenarios. A key management protocol[18] was developed with objective of reducing the amount of key transferring and communication with less storage space. A novel approach[19] was introduced for Optimizing Energy and Delay in MCSMAC Protocol. But, reducing energy consumption is not at required level. A new algorithm[20] was developed to prevent the Hotspot problem by using the Super Clustering mechanism. However, cluster efficiency obtained is not efficient.

Another New approach called PSO based Apriori[21] was illustrated for improving network lifetime and energy in wireless sensor networks. But, energy efficiency of the network is not at required level. Efficient Neighbor Coverage Routing Protocol (ENCRP)[22] was designed to reduce the routing overhead by using efficient neighbor coverage knowledge and rebroadcasting probability. However, this method does not consider the network lifetime. Another protocol[23] was developed called as cross layer energy efficient protocol that optimizes energy consumption of the sensor nodes in the wireless sensor Network. Genetic algorithm based load balancing clustering[24] was designed to balance the load between the dissimilar clusters in the wireless sensor network which in turn improved the lifetime of the network. Though, it consumes of more energy.

Hierarchical cluster based routing protocol[25] were illustrated for improving network lifetime in the WSN. But, it does not deal with cluster based routing protocol issues efficiently. Another protocol was developed called as enhanced LEACH-R[26] which introduces the energy efficiency clustering algorithm for improving the lifetime of networks in WSN. However, cluster head needs more energy for the transmission of information. An unequal clustering approach[27] was designed to reduce the overall energy consumption and to improve the network lifetime. In addition, an Energy Efficient Cluster-Chain based Protocol[28] was proposed for Time Critical applications (ECCPTC) in wireless sensor networks. Though, it improves the network lifetime and reduces the energy consumption and transmission delay of time critical data. Energy aware data aggregation with sink relocation technique[29] was introduced for improving the network lifetime. However, it requires more energy to compute and communicate data to sink. Additionally, new hierarchical routing algorithm[30] was designed to improve the performance of the WSNs. Though it improves the energy efficiency but the problems related to the distance between CH's for multi-hop communication is not consider in this method.

This study introduced the features of energy-efficient cluster-based routing and designs an Adaptive Hierarchy Cluster based on the CSI and RSI. The contributions of the LPAHC framework include the following: to reduce the average energy cost by designing a FDM-based channelization technique, to improve the network lifetime by constructing an Adaptive Hierarchy Cluster based on the probability factor and to reduce the energy consumption during node communication in WSN using RSI.

2. Design of LPAHC

In order to achieve energy preservation while communicating between nodes, the LPAHC introduces an application specific data association for sensor nodes according to the communication channel to reach the base station. Thus, to achieve high energy efficiency and increase the network lifetime, sensor nodes are organized into clusters. For this specific purpose, a new framework for collecting sensor nodes into clusters is designed in a significant manner.

This framework ensures dissemination of sensor nodes by organizing them into clusters of different size. Then, the cluster heads in the network sends the data aggregated from the network to the base station. The data aggregation in the LPAHC is performed on the basis of CSI using channelization technique. The cluster-heads are distributed in a uniform manner to minimize energy depletion rate and therefore ensure maximum energy efficiency. Hence, cluster heads are uniformly distributed across the entire area (i.e., network).

The execution of the LPAHC is performed over three parts. The first part involves the design of channelization while the second part includes the cluster head selection and data communication between the sensor nodes is the third section of our framework. Figure 1 shows the block diagram of LPAHC framework. The FDM-based channelization technique is used to measure the unused frequency bands. Through the measured unused frequency bands, the sensor nodes are allocation with corresponding channels aiming at improving the average energy cost.

Next, by designing Adaptive Hierarchy Cluster, the selection of cluster head is made on the basis of residual energy in the network than the energy consumed by each sensor node. So, the network lifetime is improved by using LPAHC framework. Finally, efficient node communication is attained using Received Signal Indicator. The Received Signal Indicator obtained from the cluster head reduces the energy consumption. The elaborate description of LPAHC framework is presented in the forthcoming sections.

2.1 Design of FDM-based Channelization

The objective of the LPAHC is to optimize channel utilization for efficient data communication between sensor nodes in network in addition to maximization of energy. With significant energy costs incurred from channel contention, the LPAHC reduces the average energy cost by performing data aggregation at forwarding nodes by performing FDM-based channelization according to the observed traffic patterns.

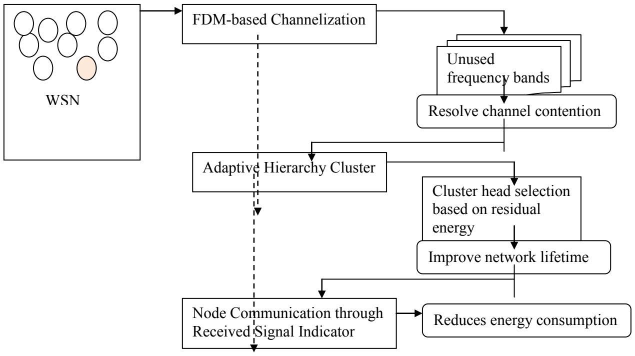

Figure 1. Block diagram of Least-Power Adaptive ierarchy Cluster (LPAHC).

The LPAHC uses the unused frequency bands for effective data communication without collisions. When the unused frequency bands increases, fewer sensor nodes participate in channel contention. So each sensor node uses unused frequency band to listen to the channel before transmitting data. If the frequency band is busy, the sensor node backs off otherwise the sensor node transmits its data to the next-hop node. The LPAHC also assumes that the frequency at which a sensor node sends data should be equal to the frequency of the receiving sensor node of its successor in the transmission chain.

Let us consider sensor nodes 'SN_i' with a network size of '$M * N$' that wants to transmit the packets 'P_i' at a certain time gap 't'. Then the LPAHC using FDM-based channelization to pass down an average of packet to content for the channel is as given below

$$C = \frac{SN_i(P_i)}{ASN_i(P_i)} \tag{1}$$

From (1), the contention using the LPAHC is the ratio of sensor node that sends a packet to the aggregated sensor nodes who all content for the channel. The FDM-based channelization in the LPAHC is responsible for assigning transmission and reception frequencies to each sensor node based on its hop distance and channel information from the sink. As a result, FDM-based channelization reduces the average energy cost by assigning effective transmission and reception frequencies.

Let us assume that each sensor node in WSN transmits the data every '$P_i(\tau)$' seconds, where '$P_i(\tau)$' is defined in such a way so as to reduce the congestion. If '$P_i(\tau)$' is too small, sensor nodes cannot send their data. On the other hand, if '$P_i(\tau)$' is too large, the channel is idle and the sensor nodes send their data consecutively and results in efficient transmission of data. The value of 'τ' is therefore selected on the basis of density of sensors, the mean hops to obtain a data to the base station 'BS' and the time required to travel single hop and is formulated as given below

$$\tau \to (SN_{i,} MH_{i,} t) \tag{2}$$

From (2), the FDM-based channelization value 'τ' is based on the sensor nodes 'SN_i', mean hops 'MH_i' in WSN and time for single travel ‘τ’. Figure shows the arrangement of FDM-based connectivity which involves nine sensor nodes ‘$SN_i = SN_1, SN_2, \ldots, SN_9$’ with two channels ‘$C_i = C_1, C_2$’ assigned with two frequencies ‘’$freq_i = freq_1, freq_2$.

From Figure 2, the first channel ‘C_1’ consists of the sender sensor node ‘SN_1’ which is assigned with the mean hop three (i.e. ‘$(SN_1 \rightarrow SN_3, SN_5, SN_8)$ denoting a frequency ‘$freq_1$’. In a similar manner, the second channel ‘C_2’ consists of the sender sensor node ‘SN_2’ which is assigned with the mean hop two (i.e. ‘$SN_2 \rightarrow SN_4, SN_6$) denoting a frequency ‘$freq_2$’. As a result, the number of channel state operations is reduced and minimizes average energy cost.

2.2 Construction of Adaptive Hierarchy Cluster

With the objective of improving the network lifetime, the LPAHC uses Adaptive Hierarchy Cluster, where sensor nodes makes decisions regarding Cluster Head ‘CH’ node or normal Sensor Nodes ‘SN’ without any centralized control. So a cluster formation is designed in such a manner that there are a certain number of clusters and uniformly distributes the energy load between all the sensor nodes in WSN. In this manner, no over-utilized nodes run out of energy before the other sensor nodes. Finally, the sensor node that has maximum energy is the cluster head node whereas the others being a non-cluster head node.

In the LPAHC, each sensor node elects itself to be a cluster head during the start of the iteration at time ‘t’ with a probability of ‘$Prob_i(t)$’. If the network with size ‘$M * N$’ includes ‘n’ nodes the selection of cluster head is formulated as given below.

$$S(CH) = \sum_{i=1}^{n} Prob_i(t) \tag{3}$$

From (3), the selection of cluster head ‘$S(CH)$’ is obtained based on the probability of nodes ‘$Prob_i$’ at time ‘t’. Upon successful selection of cluster head nodes, the cluster head nodes let all the other senor nodes in WSN to know it to be the cluster head node. This is performed through effective broadcasting of Beacon Message (BM) that includes a small message that includes the sensor node’s ID and a header comprising of announcement message. The format of BM is shown in Figure 3.

Therefore, the selection of cluster head based on the probability given in (3) is based on the assumption that all sensor nodes initiates with equal energy. If sensor nodes have different energy level, then the sensor node that has the maximum energy level becomes the cluster head node than the nodes that have lesser energy level. Therefore, the LPAHC is said to be Adaptive Hierarchy Cluster, because only on the basis of hierarchy (i.e., higher energy assigned with cluster head) the cluster head is selected. This shows that all sensor nodes in the LPAHC die at the same time ensuring network lifetime.

In order to achieve higher network lifetime, the LPAHC selects a sensor node to be the cluster head with the help of the energy prevailing in the network, rather than the frequency of times the node has been cluster head. The probability of a sensor node to become a cluster head is therefore formulated as given below

$$\sum_{i=1}^{n} Prob_i(t) = MIN\left(\frac{Energy_i(t)}{Energy_{total}(t)}\right) \tag{4}$$

From (4), the probability of node to be cluster head, $Prob_i(t)$’ is the ratio of minimum of current sensor node energy ‘$Energy_i(t)$’ to the total energy prevailing in the network ‘$Energy_{total}(t)$’. Figure 4 given below shows the selection of cluster head based on the residual energy.

In Figure 4, the sensor node ‘SN_1’ have to transmit a packet ‘P_i’ to base station ‘BS’. There exists two cluster head ‘SN_5’ and ‘SN_4’ in the network. The cluster head close

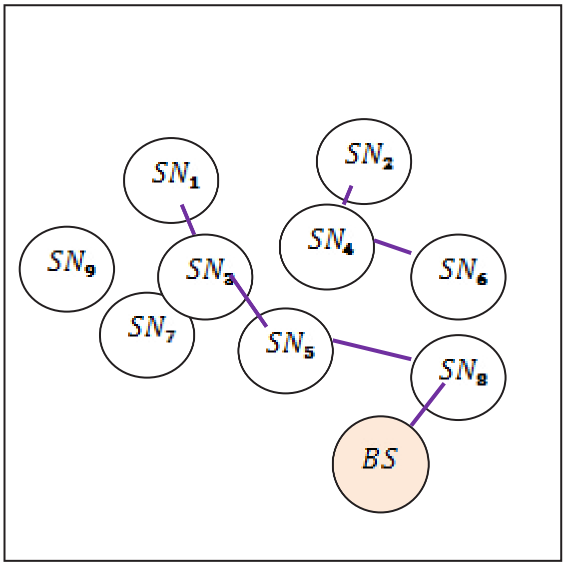

Figure 2. FDM-based channelization.

Sensor node ID	Header

Figure 3. Beacon Message.

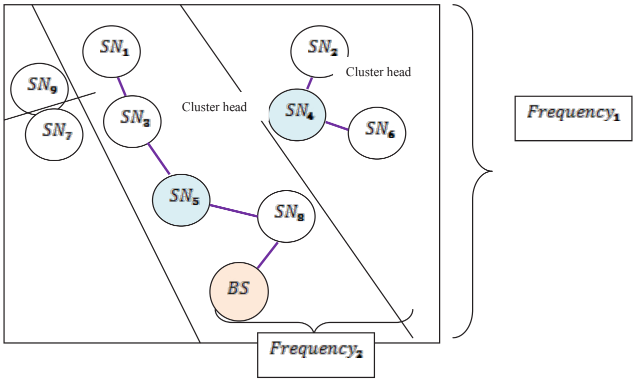

Figure 4. Residual-energy-based cluster head selection.

to 'SN_1' is 'SN_5' and so the packet is transmitted to the base station through 'SN_5'. Therefore, by selecting the cluster head based on the residual-energy, the LPAHC improves the network lifetime.

2.3 Design of Node Communication through Received Signal Indicator

Huge energy level in WSN is consumed between node communications. During node communication, the energy consumed for data transmission is higher than the energy consumed for data communication. With the increase in the data transmission distance, transmission power also increases drastically in WSN. Therefore, the distance between data transmission has to be reduced in order to minimize the energy consumption. Therefore, the LPAHC performs node communication through Received Signal Indicator (NC-RSI).

With the objective of increasing the network lifetime and to reduce the energy consumption of the sensor nodes during node communication, the sensor node in the LPAHC allocates its transmission power (i.e., RSI) greater than required power to reach cluster heads. Once the cluster head is selected, it performs data collection from its associate sensor nodes that lie within the cluster and identifies a superior sensor node 'SSN_i' to send the packet. The 'SSN_i' is selected in such a way that the RSI between cluster head 'CH_i'and superior sensor node is less than the RSI between cluster head and base station 'BS' and the formulation is as given below.

$$SSN_i \rightarrow RSI(CH_{i,}SSN_i) < RSI(CH_i, BS) \tag{5}$$

From (5), if the cluster head identifies the 'SSN_i' then the packets are sent through it. If the cluster head does not identify the 'SSN_i', then the packets are sent through the base station. In this way, the energy consumption is reduced using the LPAHC.

Figure 5 shows the Energy Efficient Data Communication (EEDC) algorithm. The EEDC algorithm with the objective of improving the average delay time consumption performs FDM-based channelization using the threshold value 'τ' and selection of cluster head is performed on the basis of residual energy. This is obtained through probability factor. Finally, the identification of superior sensor node using the LPAHC through Received Signal Indicator ensures efficient communication between sensor nodes in WSN.

3. Experimental Setup

LPAHC framework in Wireless Sensor Network uses the NS-2 simulator with network range of 1400*1400 m size. 70 nodes are selected for experimental purpose. The experimental work for LPAHC framework is conducted using Destination Sequence Based Distance Vector (DSDV) routing protocol. The moving speed of sensor nodes in LPAHC framework is about 5 m/s for each sensor node with a simulation rate of 40 milliseconds to establish communication between sensor nodes. The parametric values used for the design of LPAHC framework for performing experiments are provided in Table 1.

Experiment is conducted on the factors such as average energy cost, network lifetime, sensor node energy

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Initialize: Sensor Nodes '$SN_i = SN_1, SN_2, \ldots SN_n$', Network size of '$M * N$', Packets '$P_i = P_1, P_2, \ldots P_n$', time '$t$', Mean Hop '$MH_i = MH_1, MH_2, \ldots MH_n$', sensor node energy '$Energy_i(t)$', Base Station '$BS$'
Output: energy efficient data communication between sensor nodes
Step 1: Begin
Step 2:    For each sensor node $SN_i$
Step 3:        Perform FDM-based channelization using (1)
Step 4:        Obtain threshold value '$\tau$' using (2)
Step 5:        Perform cluster head selection using (3)
Step 6:        Evaluate probability factor using (4)
Step 7:        Measure superior sensor node using (5)
Step 8:            If $RSI(CH_i, SSN_i) < RSI(CH_i, BS)$ then
Step 9:                Packets sent through '$SSN_i$'
Step 10:           Else
Step 11:               packets sent through $BS$
Step 12:           End if
Step 13:   End for
Step 14: End
```

Figure 5. Energy Efficient Data Communication (EEDC) algorithm.

Table 1. Simulation setup

PARAMETER	VALUE
Protocols	DSDV
Network range	1400 m * 1400 m
Simulation time	50 ms
Number of sensor nodes	10, 20, 30, 40, 50, 60, 70
Network simulator	NS 2.34
Mobility speed	5 m/s
Pause time	10 s
Packets sent	7, 14, 21, 28, 35, 42, 49

Table 2. Tabulation for average energy cost

Node density	Average energy cost (J)		
	LPAHC	DRA-WSN	FMEE
10	4.78	5.45	6.12
20	5.32	7.37	10.40
30	6.86	8.91	11.94
40	6.22	8.27	11.30
50	7.12	9.17	12.20
60	7.05	9.12	12.15
70	7.28	9.33	12.36

consumption and average delay time consumed for efficient data communication between sensor nodes in WSN. The results of the metrics of LPAHC framework is compared against the existing methods such as Discrete Rate Adaptation in WSN (DRA-WSN)[1] and FMEE[2] respectively.

4. Simulation Results and Analysis

The following metrics are considered for evaluation and compare the LPAHC framework with the Discrete Rate Adaptation in WSN (DRA-WSN)[1] and FMEE[2] respectively. The metrics considered are average energy cost, network lifetime, energy consumption and average delay time utilized.

4.1 Average Energy Cost

For a sensor node, the average energy cost is the cost to receive the packet from its forwarding nodes, and the energy required to content for the channel transmitting the packet towards the base station. Hence, average energy cost is given by:

$$Energy_{cost} = E(P_i) + E(C) \qquad (6)$$

From (6), the average energy cost '$Energy_{cost}$' is the cost of energy required to receive packets '$E(P_i)$' and the energy required for the sensor node to content for a channel '$E(C)$. The Table 2 represents the average energy cost which measured in terms of Joules (J) using NS2 simulator and comparison is made with two other methods, namely DRA-WSN [1] and FMEE [2].

In this experiment, different node density in the range of 10 to 70 is considered and the average energy cost in the proposed LPAHC framework is measured and compared with the DRA-WSN[1] and FMEE[2]. Figure 6 shows the result of this experiment. As shown in Figure 6, LPAHC framework outperforms than other methods in terms of energy cost. This is because the proposed framework unlike the other methods uses the unused frequency bands and overhears the channel to sense whether the channel is busy or idle using FDB-based channelization to reduce the energy cost and minimize the contention rate.

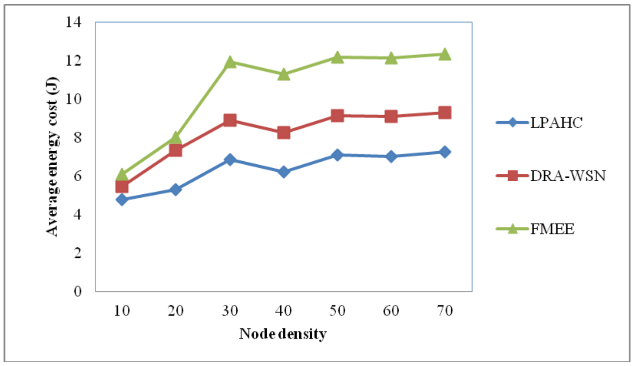

Figure 6. Measure of average energy cost.

Figure 6 shows the average energy cost with respect to node density in the range of 10 to 70. Figure 6 show that the proposed LPAHC framework provides lower energy cost when compared to DRA-WSN[1] and FMEE[2]. This is because of the application of FDM-based channelization in LPAHC framework where assignment of effective transmission and reception frequencies are performed based on its hop distance and channel information from the sink, with aiming to reduce the average energy cost by 26.27% when compared to DRA-WSN [1]. In addition to that with the data aggregation at forwarding nodes and evaluation of mean hop reduces the number of channel state operations and therefore reduces the average energy cost by 51.04% than the FMEE method[2].

4.2 Energy Consumption

Energy consumption for data transmission is the product of energy consumed by a single sensor node and the total sensor nodes in WSN.

$$EC = Energy_{SN} * Total_{SN} \tag{7}$$

From (7), '*EC*' is the data transmission whereas '*SN*' represents the sensor nodes. The consumption of energy is measured in terms of Joules. The comparison of energy consumption usage is presented in Table 3 with respect to the node density. With increase in the network size, the energy consumption also gets increased.

In this experiment, we consider different number of deployed nodes with network size in the range of 1400 m * 140 m and measure the energy consumption with total sensor nodes in the network to perform data transmission for different methods. The results of this experiment are presented in Figure 7. According to the results shown in this figure, it can be seen that LPAHC framework has the minimum energy consumption which shows that it higher amount of data transmission is being performed compared to the other methods. With the increasing of network size, the energy consumption with respect to node density is increased using LPAHC framework. This is because the node communication is performed using Received Signal Indicator which reduces the distance between data transmission in order to reduce the energy consumption.

Table 3. Tabulation for Energy consumption

Node density	Energy Consumption (J)		
	LPAHC	DRA-WSN	FMEE
10	47	55	62
20	51	56	60
30	55	61	65
40	52	58	62
50	60	66	70
60	48	54	58
70	65	71	75

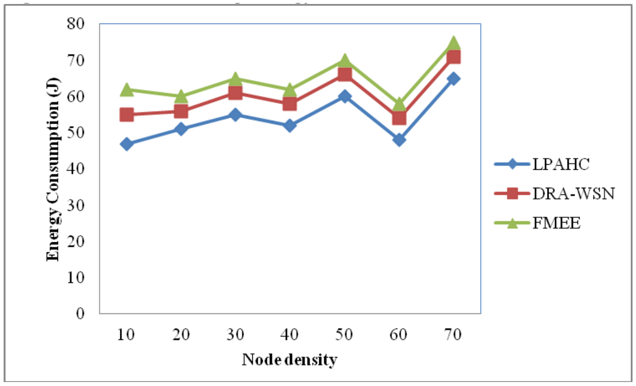

Figure 7. Measure of energy consumption.

To ascertain the performance of the energy consumption of sensor nodes during data transmission in WSN, comparison is made with two other existing methods Discrete Rate Adaptation in WSN (DRA-WSN)[1] and FMEE[2] respectively. In Figure 7, the network size or the number of sensor nodes used for performing the experiment is varied between 10 and 70 nodes.

From the Figure 7 it is illustrative that the energy consumption is decreased using the proposed Received Signal Indicator when compared to the two other existing methods. This is because with the identification of superior sensor node, the RSI between cluster head and superior sensor node and the RSI between cluster head and base station are effectively and based on it transmissions are made. Therefore, the energy consumption is reduced by 13.12% when compared to DRA-WSN[1] method. Furthermore, the identification of superior sensor node through Received Signal Indicator reduces energy consumption for data transmission by 23.64% than when compared to FMEE[2] method.

4.3 Average Delay Time

The average delay time is the time taken to transmit the packets using EEDC in WSN. It is measured in terms of milliseconds (ms) and is formulated as given below.

$$DT = Time(P_S) \tag{8}$$

From (8) '*DT*' refers to the delay time for 'P_s' packet to be sent in WSN. Table 4 given below shows the average

Table 4. Tabulation for average delay time

Packets sent	Average delay time (ms)		
	LPAHC	DRA-WSN	FMEE
7	14.32	15.60	16.50
14	18.13	23.16	30.18
21	21.35	26.38	33.40
28	20.32	25.35	32.37
35	24.89	29.92	36.94
42	22.31	27.34	33.36
49	30.15	35.18	42.20

delay time with respect to 49 packets sent with a pause time of 10 s.

In this experiment in Figure 8, we consider different density of sensor nodes in the range of 10 to 70 sensor nodes and compare the average delay time for data communication between sensor nodes of the LPAHC framework with other methods. The average delay time is defined as time for the packets to be sent to the destination node in WSN. It can be seen that for all the methods, as the number of packets increases, the average delay time also increases too. It is observed that the proposed LPAHC framework consume minimum average delay time. This is because in the proposed framework EEDC algorithm is carried out which not only ensures network lifetime of the nodes in network but also reduces the average delay time for the packet to be reached to the destination. Comparatively, the average delay time using LPAHC framework is better by 18.33% and 40.84% when compared to DRA-WSN[1] and FMEE[2] respectively.

4.4 Network Lifetime

Network lifetime in WSN is the time until the first sensor node or group of sensor nodes runs out of energy. Therefore, the network that minimizes the maximum sensor node load is the one that will ensure the maximum network lifetime and this is achieved using the proposed LPAHC framework. The network lifetime for LPAHC framework is elaborated in Table 5. We consider the framework with network range of 1400*1400 m size for experimental purpose using NS2 maintaining a mobility speed of 5 m/s.

In Figure 9, we depict the network lifetime using differing node density with a mobility speed of 5 m/s maintaining a network range of different number of sensor nodes in the range of 1400*1400 m for experimental purposes. From the figure, the value of network lifetime using the proposed LPAHC framework is higher when compared to two other existing methods DRA-WSN[1] and FMEE[2] respectively. Besides we can also observe that by increasing the node density, the network lifetime is increased using all the methods. But comparatively, it is higher in LPAHC because of the application of Adaptive Hierarchy Cluster.

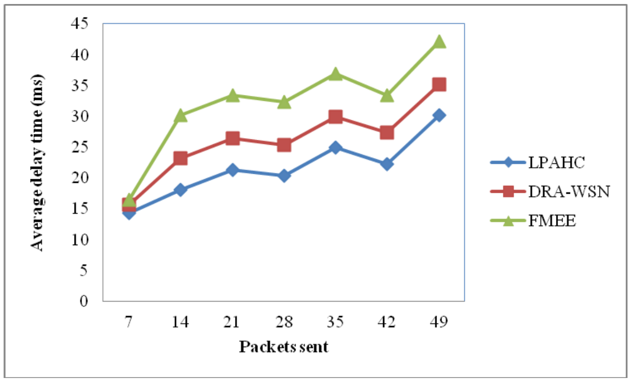

Figure 8. Measure of average delay time for data communication between sensor nodes.

Table 5. Tabulation for network lifetime

Methods	Network lifetime (ms)
LPAHC	56.38
DRA-WSN	44.13
FMEE	39.35

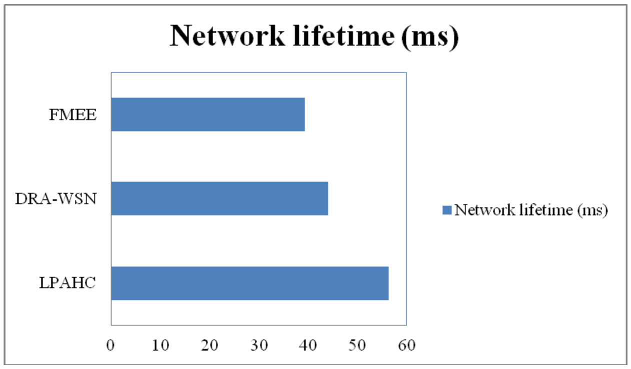

Figure 9. Measure of network lifetime

With the application of Adaptive Hierarchy Cluster, effective broadcasting of Beacon Message (BM) containing sensor node's ID and a header comprising of announcement message is sent by the cluster head nodes. As a result, only on the basis of hierarchy (energy assigned with cluster head), cluster head is selected. With the identified cluster head, the resource usage is optimized taking into consideration only the cluster head based on the residual energy rather than the overall energy, the network lifetime is improved by 21.72% and 10.83% compared to DRA-WSN[1] and FMEE[2] respectively.

5. Conclusion

In this paper, we proposed a LPAHC framework using energy-efficient cluster-based routing and improve network lifetime based on CSI to optimize these issues simultaneously. To improve the connectivity of nodes in network, an Adaptive Hierarchy Cluster with probability factor and beacon message is designed. With improved connectivity, optimization of resources or reducing average energy cost with respect to sensor nodes is made using FDM-based channelization. Finally, the optimized resources by reducing average energy cost with reduced energy consumption were provided using Received Signal Indicator and with the application of EEDC algorithm. Different simulation experiments were executed to show the performance of the proposed framework and algorithm. The results obtained from the simulations showed that with the same number of sensor nodes, LPAHC can obtain a higher connectivity rate than other methods. Moreover, due to the reduced average energy cost and CSI obtained through channelization in LPAHC, the network lifetime is increased. The results show that LPAHC offers better performance with an improvement of network connectivity by 16.27% and average delay time reduced by 29.58% compared to the state of the art works.

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