Hybrid Energy-based Secured clustering technique for Wireless Sensor Networks

P. Saveetha[1], Y. Harold Robinson[2], Vimal Shanmuganathan[3], Seifedine Kadry[4], Yunyoung Nam[5*]
[1]Department of Information Technology, Nandha College of Technology, India
[2]School of Information Technology and Engineering, Vellore Institute of Technology, India
[3]Department of AI & DS, Ramco Institute of Technology, India
[4]Department of applied data science, Noroff university college, Kristiansand, Norway
[5]Department of Computer Science and Engineering, Soonchunhyang University, South Korea
saveepme@gmail.com, yhrobinphd@gmail.com, svimalphd@gmail.com, skadry@gmail.com, ynam@sch.ac.kr

Abstract

The performance of the Wireless sensor networks (WSNs) identified as the efficient energy utilization and enhanced network lifetime. The multi-hop path routing techniques in WSNs have been observed that the applications with the data transmission within the cluster head and the base station, so that the intra-cluster transmission has been involved for improving the quality of service. This paper proposes a novel Hybrid Energy-based Secured Clustering (HESC) technique for providing the data transmission technique for WSNs to produce the solution for the energy and security problem for cluster based data transmission. The proposed technique involves the formation of clusters to perform the organization of sensor nodes with the multi-hop data transmission technique for finding the specific node to deliver the data packets to the cluster head node and the secured transmission technique is used to provide the privacy of the sensor nodes through the cluster. The residual energy of the sensor nodes is another parameter to select the forwarding node. The simulation results can show the efficiency of this proposed technique in spite of lifetime within the huge amount data packets. The security of this proposed technique is measured and increases the performance of the proposed technique.

Keywords: Wireless sensor networks, Energy utilization, Multi-hop data transmission, Residual energy, Cluster head

1 Introduction

The WSNs is used to monitor the surroundings for generating the real-time information and to increase the performance of the WSN [1]. According to the various problems, the data collection will be the main issue and transmit the data packets in the network [2]. The cooperation from the sensor node will involve the advantage of secured data transmission. The main functionality for the sensor node is to monitor the communication area and deliver the information. The topology changes are happen in the network for wireless communication so that the network may acclimatize the environment changes [3]. The capability for the single node is very much restricted that the Reachability to monitor the environment in the communication range. Whenever the network is deployed, it is very hard to change the energy supply of the sensor node [4]. Owing to the restricted energy to gather the huge amount of data is another problem in WSN communication model. Several protocols are developed to construct the communication model that the cluster head has directly communicated with the base station for data transmission [5].

The WSNs is utilized to access the time based critical metrics for reliable prediction of efficient detection in the surroundings. The constructed framework has established the prediction to provide the proficient energy consumption for the resource oriented conscientious sensors [6]. Additionally, the time augmented sampling information is implemented for providing the detection in the surrounding outbreak. The WSN based surveillance applications can present an efficient framework to accumulate the situation based knowledge for providing the enhanced security parameters. The most of the existing methods are focusing on the abnormal events through the centralized video surveillance system with WSNs [7].

The wireless sensor network is the widely used network with several amount of sensor nodes utilize the sensing of information from a specific area to transmit it to the base station [8]. It has restricted resources for transmitting and processing of sensing information. The energy efficient is the primary problem in WSN with the mobility technique. The mobile sink is utilized for gathering the data and transmitting it in a random path. WSN also produces several real-time applications which are used in industrial and agriculture field [9]. The sensors are used for supporting the irrigation system, fertilizing and also seeding in agriculture sectors. This will help the formers to utilize the weather conditions well and also identifying the diseases easily with restricted amount of resource utilization. The poor deployment of the senor nodes will cause the coverage hole problem and causes problem in energy utilization [10]. For implementing clustering process, the sensor nodes divide into several clusters for data communication. Within the sensor nodes, a single node is selected as the cluster head after satisfying the different constraints of sensor nodes.

Cluster head is responsible for communication of data packets into the base station. MLBC [11] technique is implemented to produce the cluster balance with achieving reliability and enhanced residual energy. EA-DB-CRP [12] has implemented to produce the density related energy utilization with efficient routing technique; it facilitates the data communication within the base station and the sensor

* Corresponding Author: Yunyoung Nam; E-mail: ynam@sch.ac.kr
DOI: 10.53106/160792642022012301003

node. The suitable path is identified using efficient routing technique to transmit the data packets. MOFPL [13] has been implemented to generate the enhanced energy consumption by multi-objective based fitness function for optimized routing.

The network lifetime is another key parameter to explore the WSN in real-time scenario and used to solve the deployment related problems. Each node uses the battery energy whenever data communication either transmitting the data packets or receiving the data packets, it will be a critical factor for designing the efficient WSN. The cluster related routing methods have been designed to increase the energy utilization while performing the cluster head selection and data transmission in WSN. The developed WSN will have the solution to the challenges of constructing the network with new dimension of issues.

The advancements in the WSNs have motivated the minimum cost and low energy consumption equipment's. The sensors have the signal processing system for sensing the devices that generate the initiation of the wireless transmission. The WSNs have several real-time applications that gather the information from the adjacent nodes and forwards the information with sensed information to the sink node in the active transmission methodology. The WSNs will monitor the surroundings and transfers the sensed information to the user readable format. WSN envelop several applications that include the military, hospital and home based automation system. The main contribution of the WSN is to enhance the lifetime of the network when the beginning node is unable to broadcast the information to the sink node. The data gathering for every node is dependable for information gathering of the data packets into the sink node. The aggregation procedure involves the reduction of data traffic and saves the energy by combining dissimilar data packets into one packet. Therefore several applications are constructed for enlarging the lifetime of the network.

The main contribution of the proposed technique is:

1. The proposed methodology tends to concentrate in energy-efficiency of the network by electing CH on the basis of which holds high energy in terms of residual energy, less distance to BS and threshold energy.
2. The proposed technique is constructed to select the cluster head according to the node residual energy, distance factor and number of neighbouring nodes.
3. A new routing technique is implemented in the proposed work to increase the data delivery rate and to enhance the network performance.
4. The performance of the proposed technique is verified with the latest existing methodologies using NS2 simulation.

2 Related Work

Most research is carried out in the energy-efficiency protocols in WSNs. The traditional LEACH protocol [14] stands first in this area. LEACH follows that all the nodes are given a threshold value and each node is requested to choose a value between 0-1 in random. The node which holds lesser random value than the threshold value is elected as CH. The other nodes will act as member nodes to CH for this round. LEACH follows TDMA schedule to send the data to BS in a given period of time which reduces congestion between nodes. This process is continuous in each round. The H-LEACH [15] is introduced in which concentrates in energy optimization in election of channel head. It also considers threshold function for election of head. The node which holds maximum residual energy is also considered for election and the node. The head node is chosen between the node holds higher threshold energy and the node considers maximum residual energy. These schemes perform better than LEACH and HEED protocol [16] but still the election process spends more energy of a node which reduces lifetime of the network.

Energy of power consumption is the main area to be concentrate to increase lifetime of the network. Thus, the P-LEACH [17] is used for producing the optimal cluster-based chain protocol is widely concentrating by developing a novel algorithm to transfer data. This model combines both PEGASIS [18] and LEACH protocol model and identifies a novel approach to reduce the consumption of energy which mainly consumes in sending the data over the network. The enhanced scheme [19] introduces new dynamic data transfer model to transfer data between the nodes. Though this scheme improves the lifetime, it lacks in effective CH selection. A novel energy efficient CH selection and rotation mechanism has implemented to reduce the energy consumption and repeated cluster forming in each round. This can be obtained by transferring CH from a node to nearest node of the same cluster which can able to communicate all the member nodes based on the signal indicator process. The signal indication is stored in NODE packet which also consists of the node ID which is going to act as CH for next round thus, made the rotation of CH without forming the clusters in each round. This scheme reduces the FND (First Node Die) ratio compared to the existing schemes. ANEC detection technique [20] has been implemented for compromising the detection in a cluster related WSN to provide the security.

Taylor C-SSA [21] technique has been implemented for addressing the energy related problems in multi-hop routing while selection of cluster head and forwarding the data. LEACH protocol is utilized for producing the optimized selection of cluster head which communicates the data to the base station. The WSN enabled IoT routing has been performed through the enhanced technique of EECRP [22] which has the centric routing model. An improved cluster formation in a distributed manner that maintains the self construction of the sensor nodes and position based cluster head rotation has been distributed the energy within the sensor nodes. While communicating the longer distance, the technique has been used to minimize the energy utilization and generating highest residual energy. The LEACH-C [23] technique was proposed to construct the group of cluster head nodes which are used to process the data in a particular way, consider the performance parameter as residual energy and compute the summation of the distance from every cluster heads to the sensor nodes for optimized solution. GSTEB protocol [24] has been constructed with the tree related routing that produces the shortest path within the sink and the nodes.

3 Proposed Work

WSNs play a vital role for data gathering and transmitting data to produce the highest reliability. The multi-hop routing procedure is the main parameter to transmit the high amount of data and produce the enhanced network lifetime. The multipath routing methods has an advantage of resource utilization and load balancing by minimizing the routing failures like packet drops.

The multi-hop path identification procedure is related with the mathematical formation to reduce the routing overhead and minimized end-to-end delay. The network congestion is high for single path data transmission; the procedure with passive routing technique will find the initialization process in the network to save the routing related data and the sensor nodes require the data communication can discover the useful path through the routing table information. The energy proficient routing procedure with multi-hop routing is implemented for data transmission in WSNs. The overhead is reduced using this kind of procedure and increase the network lifetime and the sink node is used to allow the communication of constructed cluster head to transmit the data packets. The scalability of the WSN is increased and the utilization of the sink nodes has afforded to optimize the energy utilization in the network. The sensor nodes are constructed to discover the appropriate sink node from the set of adjacent nodes and it doesn't need the whole communication path in WSNs. The important parameter for the sensor node is computing the energy and the storage capability. The storage routing data is required for restricted storage space and the main problem for this procedure is the possibility of updating the routing table data in dynamic manner and the entire architecture is demonstrated in Figure 1.

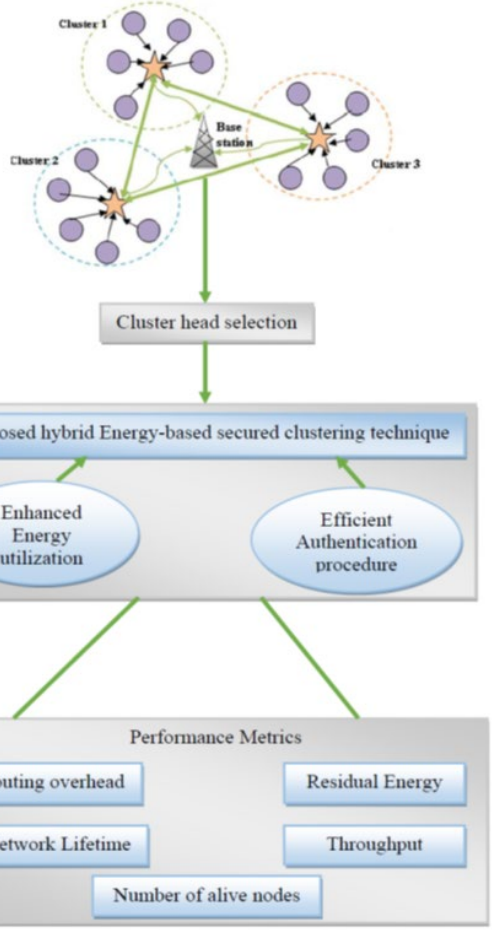

Figure 1. Proposed HSEC architecture

In the GPS model sensor nodes can act as self-organised, they must generate communication with adjacent nodes according to the position. This GPS can execute routing like flooding, discovery of path and energy utilization. Minimum energy transmission path is constructed according to the spanning tree from sink as root to leaf node. This property implies energy efficient routing protocol by using the GPS data for WSN.

The random deployment is used for the WSN that every node is active and it is very useful for selecting the cluster heads. The proposed technique is used to increase the coverage area by the random deployment of nodes with useful node density among the 2-dimensional areas. Theses sensor nodes are deployed in the independent communication range. The optimal collection of data is used to increase the data transfer rate and is identified as $\frac{Radius}{2}$. The classification of the environment is fixed with the sensor node and the storage values using the Geo-spatial positioning system is having the value of latitude and longitude values. The reliable data is gathered and the adaptability is maintained. Figure 2 demonstrates the transmission range for communication of the data packets.

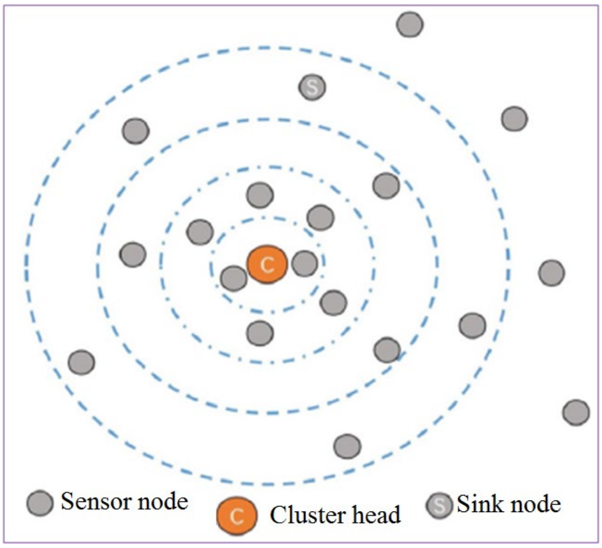

Figure 2. Transmission range

The spatial coordinate values are measured according to the communication based data accumulation for providing the processing of short-term analysis. The accumulated data has communicated the spatial based coordinate values in the network. Algorithm 1 demonstrates the classification of environment using the Geo-Spatial positioning system.

Algorithm 1. Classification of the environment

Step 1: Select the most computable area in the region.
Step 2: The co-ordinate values are selected as the x-axis contains the minimized elevation value (-x) to the maximized elevation value (+x).
Step 3: The radius of the particular range is computed as the half of the sensor transmission range as $\frac{Radius}{2}$.
Step 4: Fix the IoT sensor into the centre of the communication range.
Step 5: Store the values of latitude and longitude with Geo-spatial positioning system.

Energy is the major concern for sensor nodes which are deployed randomly for monitoring the environment. The utilization of energy has optimized to prolong the network lifetime. For the purpose of monitoring the environment, the sensor nodes are capable of capturing the small changes within the specified time slots. Normally, the humidity and the temperature data are measured to enhance the adaptability of the sensor nodes. By reducing the redundant data, the optimized energy utilization is performed by the sensor nodes in the network. The proposed technique has implemented this concept of energy optimization. For the deployment of the network, within every time periods, TS_p generates the specified time periods TS_s with the vector values in Eq. (1)

$$V_k = \{da_1, da_2, da_3, \ldots, da_{TS-1}, da_{TS}\} \quad \textbf{(1)}$$

The proposed technique utilizes the variance model to identify the comprehensive variation (δ_{cv}) is received by the sensor node $Node_k$ in total amount of time periods. The comprehensive variation is computed using the variation in periods (δ_{vip}) and the variation among the periods (δ_{vap}) and it is computed using Eq. (2)

$$\delta_{cv} = \delta_{vip} + \delta_{vap} \quad \textbf{(2)}$$

Eq. (3) demonstrates the variance model for the computational process.

$$\sum_{x=1}^{N}\sum_{y=1}^{n_x}\left(da_{yx} - \alpha_{mean}^{x}\right)^2 + \sum_{x=1}^{N} n_x\left(\alpha_{mean}^{x} - \alpha_{mean}\right)^2 \quad \textbf{(3)}$$

The variation within the sensor node data from the different time periods maximizes the particular threshold value (P_{th}). The needed energy consumption from the specified time periods has computed in Eq. (4).

$$\Gamma_{tot} = \sum_{y=1}^{n_1} da_{1y}^2 + \sum_{y=2}^{n_2} da_{2y}^2 + \cdots + \sum_{y=1}^{n_N} da_{Ny}^2 - \frac{\left(\sum_{y=1}^{n_1} da_{1y}^2 + \sum_{y=2}^{n_2} da_{2y}^2 + \cdots + \sum_{y=N}^{n_N} da_{Ny}^2\right)}{n_N} \quad \textbf{(4)}$$

The summation of the inter period is computed using Eq. (5)

$$\Gamma_{amo} = \frac{\left(\sum_{y=1}^{n_1} da_{1y}\right)^2}{n_1} + \frac{\left(\sum_{y=1}^{n_2} da_{2y}\right)^2}{n_2} + \cdots + \frac{\left(\sum_{y=1}^{n_N} da_{Ny}\right)^2}{n_N} - \frac{\left(\sum_{y=1}^{n_1} da_{1y}^2 + \sum_{y=2}^{n_2} da_{2y}^2 + \cdots + \sum_{y=N}^{n_N} da_{Ny}^2\right)}{n_N} \quad \textbf{(5)}$$

The intra period square summation is calculated in Eq. (6)

$$\Gamma_{in} = \Gamma_{tot} - \Gamma_{amo} \quad \textbf{(6)}$$

The inter period mean value is computed in Eq. (7)

$$\gamma_{amo} = \frac{\Gamma_{amo}}{N-1} \quad \textbf{(7)}$$

The intra period mean value is calculated in Eq. (8)

$$\gamma_{in} = \frac{\Gamma_{in}}{n_N - N} \quad \textbf{(8)}$$

The threshold value is computed in Eq. (9)

$$\rho = \frac{\gamma_{amo}}{\gamma_{in}} \quad \textbf{(9)}$$

In the proposed technique, the sensor node data is gathered the active time period to discover the threshold value, the adjacent active nodes with time periods are computed. The active time period is calculated in Eq. (10)

$$TP_{x+1}^{Act} = TP_a \quad \textbf{(10)}$$

The passive time period is computed in Eq. (11)

$$TP_{x+1}^{Pas} = TP_p \quad \textbf{(11)}$$

If ρ< ρ_th, the active time period is minimized and the passive time period is maximized, the active time period with particular condition is computed in Eq. (12).

$$TP_{x+1}^{Act} = TP_a\left(\frac{\rho_{th} - \rho}{\rho_{th}}\right) \quad \textbf{(12)}$$

The passive time period with condition is calculated in Eq. (13)

$$TP_{x+1}^{Pas} = TP_p\left(\frac{\rho_{th} + \rho}{\rho_{th}}\right) \quad \textbf{(13)}$$

Algorithm 2 demonstrates the enhanced energy utilization with the input of data for sensor node with time periods and threshold value and produced the output of active time period and passive time period.

Algorithm 2. Enhance energy utilization

Input: data for sensor node of the time periods, threshold value
Output: The active time period TP_{x+1}^{Act} and the passive time period TP_{x+1}^{Pas}
Begin Procedure
    For every sensor node $Node_k$ do
    Store the data gathered within the time periods x-1 and x
    If the current mode is in active condition then
    Calculate the value of ρ
    end if
  if $\rho \geq \rho_{th}$ then
    Calculate $TP_{x+1}^{Act} = TP_a$
    Calculate $TP_{x+1}^{Pas} = TP_a$
  else
    Compute $TP_{x+1}^{Act} = TP_a\left(\frac{p_{th} - p}{p_{th}}\right)$
    Compute $TP_{x+1}^{Pas} = TP_p\left(\frac{p_{th} + p}{p_{th}}\right)$
  if current mode is in passive condition then
    Forward the signal based on the wake up after TP_x^{Pas} time period
  end if

End for
End procedure

The sensors are deployed for monitoring the continuous improvement in the environment to gather the initial information is a challenging work. The dimensionality of the data gathering is used for minimizing the total amount of redundant data with minimized amount of processing time. The decomposition procedure is adapted for reducing the dimensionality. The cluster head selection procedure is demonstrated in Algorithm 3.

Algorithm 3. Cluster head selection

Begin Procedure
For every sink node in the network
if ($Time_{maxi}$ < $Time_{msg}$) then
$Hop_{count} = Msg(Hop_{count})+1$
$Update_{data}$
else
Forward ($Packet_{ID}$, $Node_{ID}$)
end if
End for
For every value in $Node_{data}$
Update routing table with $Node_{data}$
Compute Th_{Node}
Select the node which satisfy the Th_{Node} is the cluster head
End For
End Procedure

The selection of cluster head for active data transmission in WSNs is based on the time consumption and the threshold value for the particular node. The Node information is generated through the hop count and the threshold value is generated to select the cluster head within the sensor nodes in the network. Figure 3 demonstrates the cluster head selection methodology that the clusters are formed and it will be communicated with the sink node.

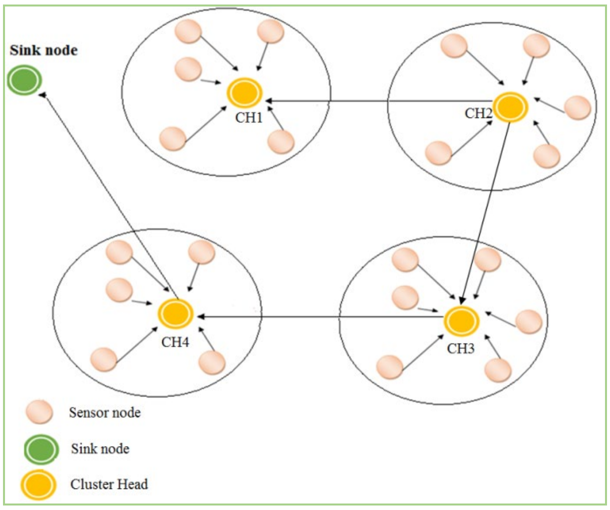

Figure 3. Cluster head selection

Based on the node deployment, the environment is divided into 2-dimensional as the nodes are deployed on the environment which is assumed as circular space. The nodes are classified as the regular node, receiving node and cluster head, the regular node is capable for sensing the environment and forward the sensed data to the receiving node. After collecting the message from the regular node, important message is transferred to the cluster head based on the time and threshold value.

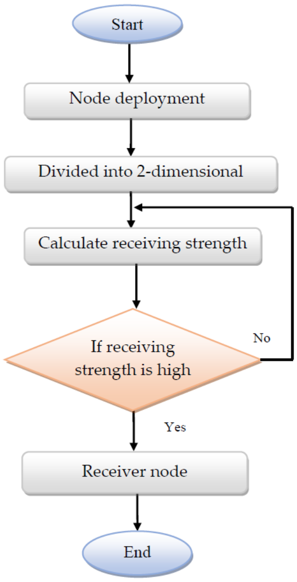

Figure 4. Receiving node

In multi-hop routing, the active cluster head will check time and energy utilization then the hop count will increase and forward the data to the next active cluster head. Finally, it reaches the sink while the authentication process will continue. The active cluster head should have the minimum time and maximum energy utilization, it will improve the clustering. The receiving nodes are used to select the cluster head according to the high energy and better network lifetime. The proposed technique is used to select the cluster head for every cluster optimally with every round of data communication which has the improved network lifetime and utilized network process that the cluster heads are used for delivering the data to the base station. Figure 4 demonstrates the entire process of the receiving node. Figure 5 illustrates the regular node process.

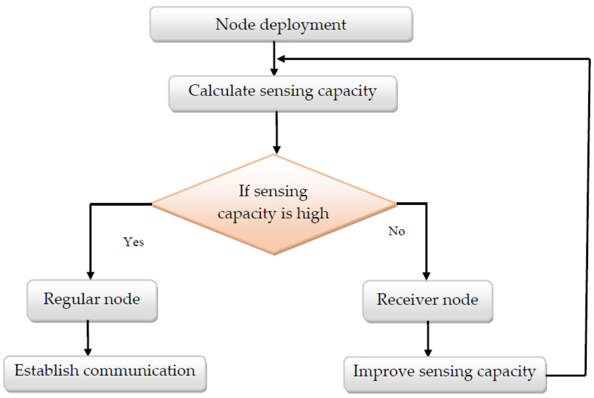

Figure 5. Regular node

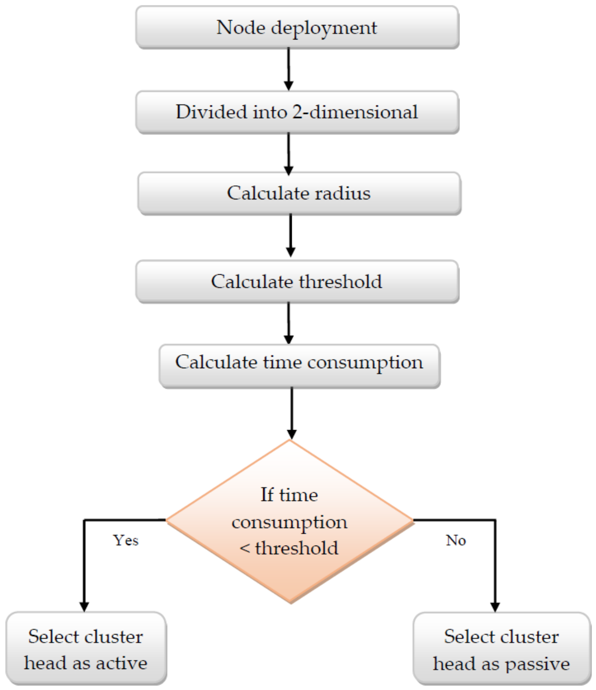

Figure 6. Cluster head

The cluster head is divided by passive and active that the cluster head which is having as time < threshold act as the cluster head. The cluster head is acted as the active within the signal range and the gathered data could be transmitted to the sink. The cluster head selection is the main factor that affects the network lifetime and also used to solve the optimal problem. The cluster head selection related messages and control information are exchanged within the sensor nodes while performing the routing process. Figure 6 demonstrates the cluster head operation. The efficient authentication procedure is demonstrated in Algorithm 4.

Algorithm 4. Efficient authentication procedure

Begin Procedure *Efficient_Authentication* ( )
For every sensor nodes in the cluster
Compute the Cl_{ID}, CL_{pw}
Compute $Cl^*_{RK} = hash\ (Cl_{ID} \,||\, Cl_{pw} \,||\, bi_{va})$
if $Cl^*_{RK} = Cl_{RK}$ then
Discover $cluster_{node}$
Compute $\tau = Cl_{RK} \oplus cluster_{node}$
Compute $\varphi = (cluster_{node} \oplus Cl_{ID} \,||\, bi_{va}) \oplus cluster_{node}$
Compute $\omega = Cl_{UK} \,||\, cluster_{node} \oplus Cl_{ID} \,||\, bi_{va})$
end if
Forward the $Message_1\ (\tau, \varphi, \omega)$
End for
End Procedure

The Efficient authentication procedure is used to provide the security for the cluster based data transmission. Every cluster node contains the cluster identifier and password and this information is stored in the table, the random key is generated using the hash function through the binary value to strengthen the security process. The original and the generated values of cluster based random key is having the same value then the process of identifying the best cluster node in the network has been done. The XOR function is utilized to compute the values of first, middle and the last values through the cluster node, cluster unique key and the binary value. Figure 7 demonstrates the Node-to-cluster head authentication, Figure 8 illustrates Cluster head -to- cluster head authentication and Figure 9 denotes the Cluster head -to-sink authentication.

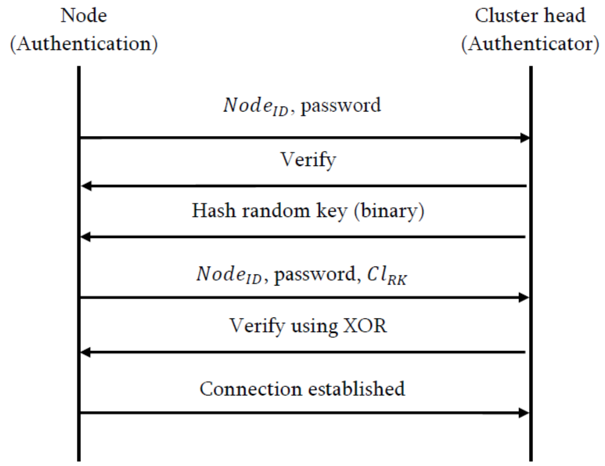

Figure 7. Node-to-cluster head authentication

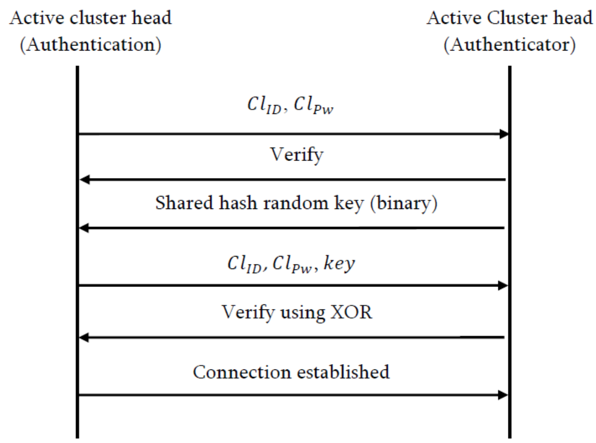

Figure 8. Cluster head -to- cluster head authentication

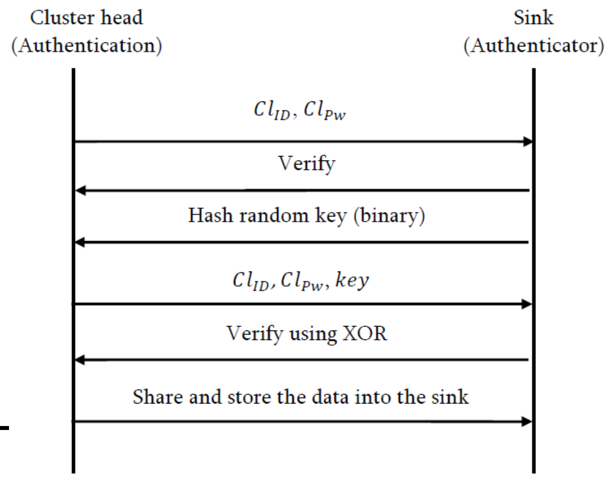

Figure 9. Cluster head -to-sink authentication

Table 1 demonstrates the notations and symbols are used in this paper.

Table 1. Notations used for the proposed technique

Notation	Value

TS	Timeslot
V_k	vector value
da	data generated by the sensor node
δ_{cv}	comprehensive variation
$Node_k$	sensor node
δ_{vip}	variation in periods
δ_{vap}	variation among the periods
da_{yx}	data from the sensor node
N	total amount of periods
α_{mean}^{x}	mean value of the data within the time period
α_{mean}	total mean value of the data
P_{th}	threshold value
Γ_{tot}	summation of the total value
Γ_{amo}	summation of the inter period
Γin	intra period square summation
γ_{in}	intra period mean values
γ_{amo}	inter period mean values
TP_{x+1}^{Act}	Active time period
TP_{x+1}^{Pas}	passive time period
Cl_{ID}	Cluster ID
Cl_{pw}	cluster password
Cl^*_{RK}	generated random key value for the cluster
Cl_{RK}	original random key value for the cluster
$Cluster_{node}$	cluster node
bi_{va}	binary value
Cl_{UK}	unique key for the cluster
τ	first value
φ	middle value
ω	last value
$Time_{maxi}$	maximum time for transmission
$Time_{msg}$	time taken for generating message
Hop_{count}	hop count
$Packet_{ID}$	packet identifier
$Node_{ID}$	node identifier
$Node_{data}$	node information
Th_{Node}	Threshold value for the node

4 Performance Evaluations

The Network simulator (NS2) is used to perform the simulation and the WSN nodes are deployed randomly in a communication range and the deployment is illustrated in Figure 10.

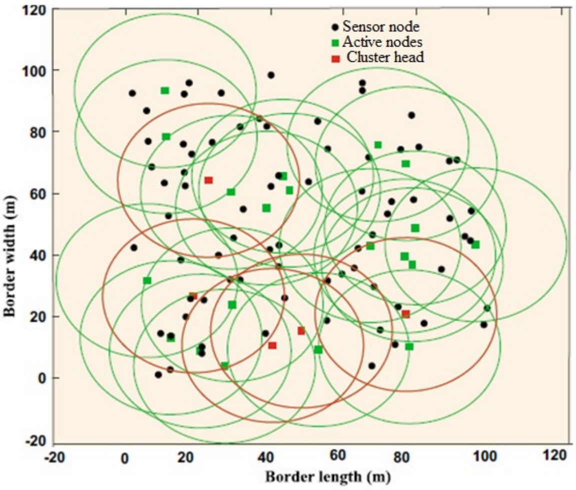

Figure 10. Deployment of sensor nodes

The proposed technique is compared to the relevant techniques of Taylor C-SSA [21], EECRP [22], LEACH-C [23] and GSTEB [24]. The simulation parameters are demonstrated in Table 2.

Table 2. Simulation parameters

Parameters	Value
cluster size	150 x 150 m^2
space of the propagation	free space
type of the protocol	IEEE 802.11
limit of the propagation	-100 dB
type of traffic	CBR
size of the message	1000 bits
size of the packet	5010 bits
speed of the data transmission	2.5 Mbps

An entropy characteristic has been defined by the reason of deploying heterogeneous wireless sensor networks and rotating epoch became ineligible. In clustering, entropy value is predicted by each of the node in the network automatically. In the next process the node which is having high residual energy will mark as possible cluster head List. The result of cluster head selection, the node which is having high entropy will be selected as cluster head. It shows correlative measure of residual and original energy.

The entropy is the randomized procedure for ensuring the security using the data that the random sets has no particular steps to provide the pattern which is gathered through randomness generators. The entropy is utilized through hash function that the keys having the algorithmic representation. The entropy is computed for the total amount of bits with the rounds and it is demonstrated in Figure 11.

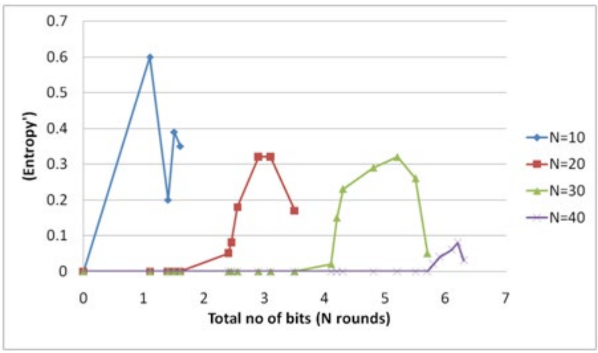

Figure 11. Entropy with total amount of bits

Figure 12 demonstrates the routing overhead with respect to the mobility speed; this process will determine the efficiency of the routing procedure in WSNs. The simulation result shows that the proposed method has the minimum amount of routing overhead compared with the relevant techniques.

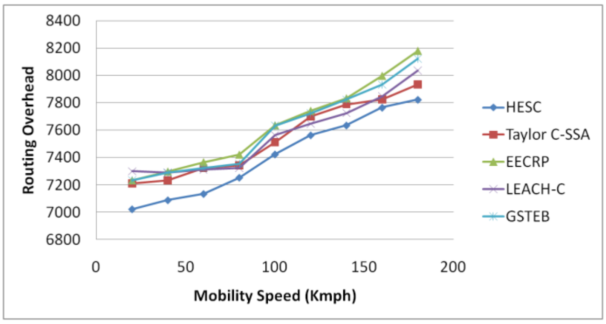

Figure 12. Routing overhead

The network remaining energy is computed that the balanced energy after the transmission of the data packets in a secured data transmission in WSNs. Figure 13 demonstrates that the proposed technique has the improved network remaining energy compared to the relevant techniques in a particular time frame. The residual energy in the sensor nodes which are computed before the initial node dies; the energy consumption in every round is used for performance parameter comparison. The energy consumed by the network is minimum value for active routing in the network.

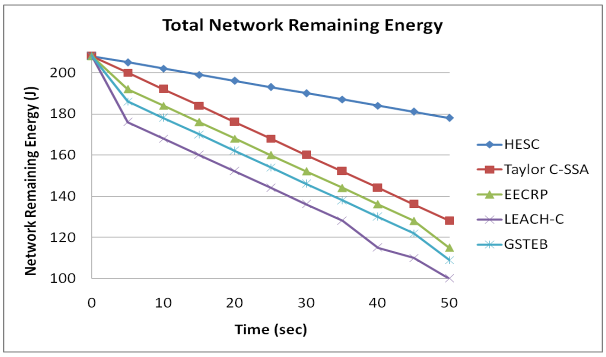

Figure 13. Network remaining energy

A sensor node is declared as an active node whenever its energy is more than zero that the performance evaluation has been analyzed for dissimilar rounds starting with 100 nodes for measuring the network lifetime. The experimental results proved that the total amount of active nodes in the network for the proposed methodology is larger than the related techniques. The energy is the prime factor that the nodes preserve the energy by generating the remaining balance load of the cluster head. A sensor node is declared as an active node whenever its energy is more than zero. A sensor node is declared as an alive node which can able to transmit data and it can receive data. Alive node can be active node or passive node based on the environment monitoring. All the alive nodes may not be active node. The amount of active nodes in the network is demonstrated in Figure 14.

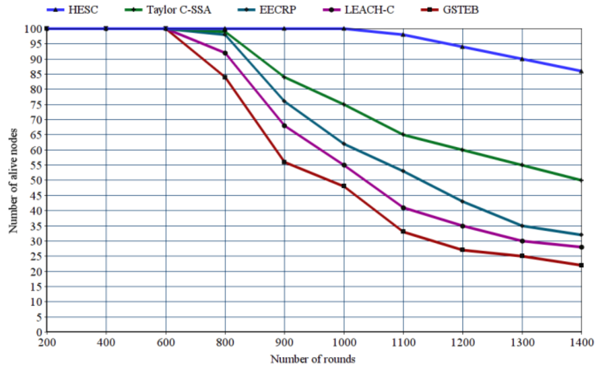

Figure 14. The amount of alive nodes

For the proposed methodology, every node combines with the cluster head by computing the residual energy and the distance are the primary factor for cluster formation procedure. The balancing load within the cluster head enhances the network lifetime by delaying the initial node's death in the network. The mean lifetime for several repeated performance of the proposed technique and the related technique, whenever the routing process has been completed, the proposed technique is well utilized for active routing. The experimental results proved that the proposed technique maintains the enhanced network lifetime compared with the relevant techniques which is demonstrated in Figure 15, Figure 16 demonstrates the average network lifetime and the standard deviation network lifetime in Figure 17.

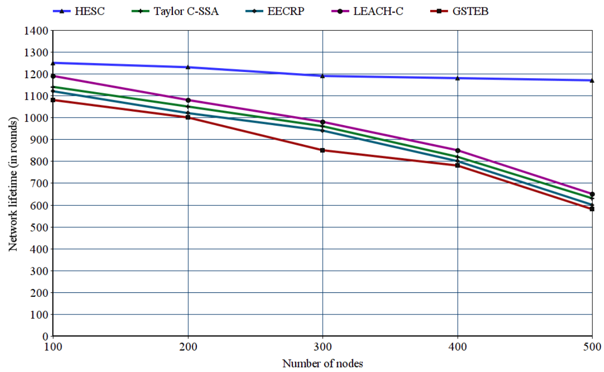

Figure 15. Network lifetime

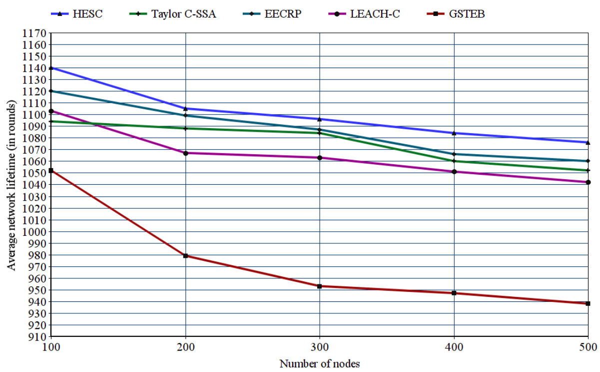

Figure 16. Average network lifetime

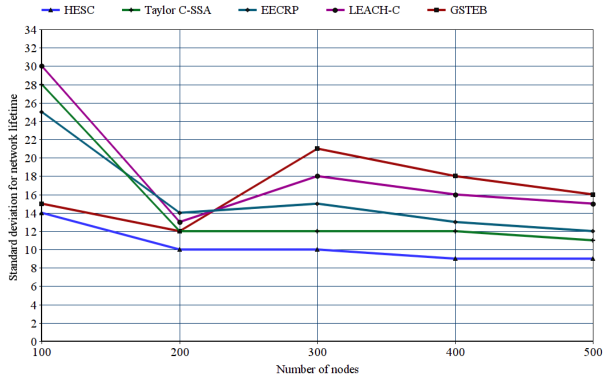

Figure 17. Standard deviation for network lifetime

The cluster sizes which are computed with the total amount of members included in every cluster for the proposed method and the related methods are computed. The variation in the total amount of clusters in every cluster is minimum in our proposed technique than the related methods while generating the clusters, every node is combined with the cluster head and the total amount of nodes, the space within the node and the cluster head which is identified with similar size in Figure 18.

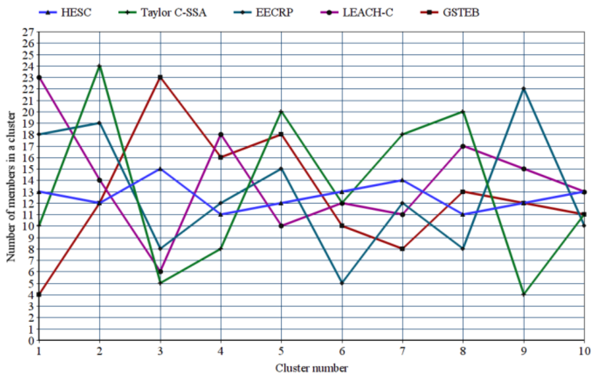

Figure 18. Number of members in a cluster

The average throughput of the proposed technique has been attaining the highest exploration rate without the particular deviation is higher than the related techniques in Figure 19.

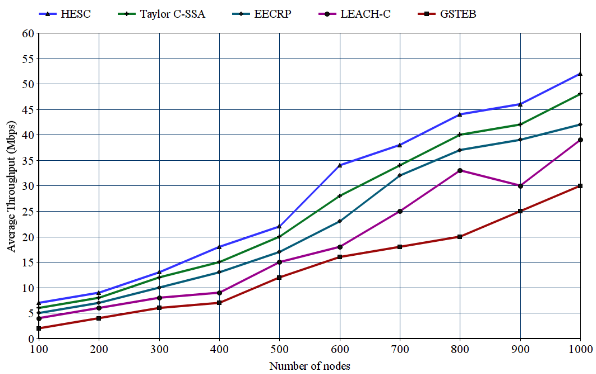

Figure 19. Average Throughput

In the beginning state, the proposed technique has been evaluated with the total amount of alive nodes and dead nodes are identified through dissimilar amount of rounds from 0 to 2000. The alive nodes in the network are stored the energy for producing the optimized solution. Moreover, the proposed technique is utilized to select the cluster heads by maintaining the enhanced network lifetime. The sensor nodes having minimized amount of energy are identified for load balance maintenance in Figure 20.

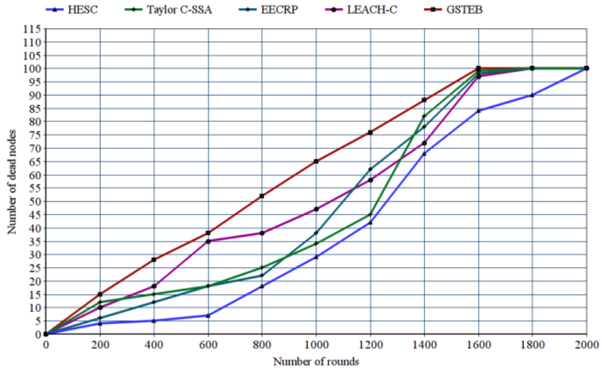

Figure 20. Number of dead nodes

The proposed technique has the minimized communication overhead percentage with dissimilar amount of sensor nodes are deployed in the network. The sensor nodes are avoided the packet loss according to the significant cluster head selection procedure, reducing the energy drain and maintaining alive nodes to the highly effective energy related load balancing procedure in the network in Figure 21.

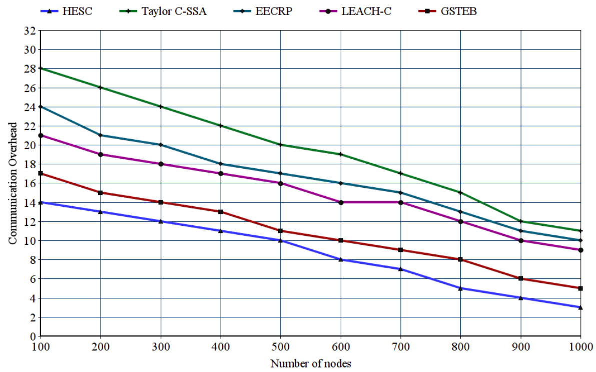

Figure 21. Communication overhead

The control packet is delivered in a specific channel and implementing the routing through specific data to the forwarded node unless the data burst happens. The control overhead is decreased through the deployment of multi-hop routing framework that several control packets are exchanged within the nodes and cluster heads. The control overhead is used to identify the efficiency while active transmission of data packets. The proposed technique is used to decrease the control packets while providing network convergence to the sensor nodes that are involved for the active transmission and Figure 22 demonstrates the control overhead comparison.

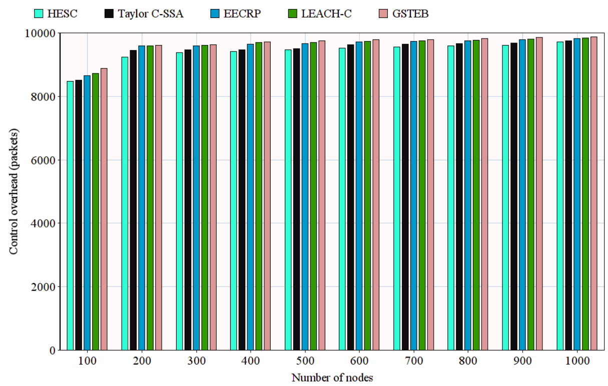

Figure 22. Control overhead

5 Conclusion

The proposed hybrid energy-based secured clustering technique is implemented in WSNs to utilize the energy in efficient way through the cluster based data transmission. The multi-hop path identification in a secured way with the adjacent nodes is constructed to provide the security to the sensor nodes. The time complexity of the proposed technique is compared with the existing approaches and the performance result has proved that the proposed technique has reduced amount of time complexity. The simulation results show that the proposed method is performed well in spite of data transmission and produce the data transmission in an efficient way. From the performance analysis, when number of nodes is increased, the control overhead will be reduced. The direct advantage of these comparisons shows that conservation of energy due to reducing free space loss.

Conflict of interest

Declaration of Interest Statement: The authors declare that they do not have any conflict of interests. This research does not involve any human or animal participation. All authors have checked and agreed the submission.

Acknowledgments

This research was supported by a grant of the Korea Health Technology R&D Project through the Korea Health Industry Development Institute (KHIDI), funded by the Ministry of Health & Welfare, Republic of Korea (grant number: HI21C1831) and the Soonchunhyang University Research Fund.

References

[1] T. Sood, K. Sharma, LUET: A novel lines-of-uniformity based clustering protocol for heterogeneous-WSN for multiple-applications, *Journal of King Saud University - Computer and Information Sciences*, pp. 1-14, October, 2020.

[2] M. R. Senouci, A. Mellouk, A robust uncertainty-aware cluster-based deployment approach for WSNs: Coverage, connectivity, and lifespan, *Journal of Network and Computer Applications*, Vol. 146, Article No. 102414, November, 2019.

[3] A. Wang, J. Shen, P. Vijayakumar, Y. Zhu, L. Tian, Secure big data communication for energy efficient intra-cluster in WSNs, *Information Sciences*, Vol. 505, pp. 586-599, December, 2019.

[4] K. Karunanithy, B. Velusamy, Energy efficient cluster and travelling salesman problem based data collection using WSNs for Intelligent water irrigation and fertigation, *Measurement*, Vol. 161, Article No. 107835, September, 2020.

[5] B. Rambabu, A. V. Reddy, S. Janakiraman, Hybrid Artificial Bee Colony and Monarchy Butterfly Optimization Algorithm (HABC-MBOA)-based cluster head selection for WSNs, *Journal of King Saud University - Computer and Information Sciences*, pp. 1-11, December, 2019.

[6] K. N. Dattatraya, K. R. Rao, Hybrid based cluster head selection for maximizing network lifetime and energy efficiency in WSN, *Journal of King Saud University - Computer and Information Sciences*, pp. 1-11, April, 2019.

[7] V. Nivedhitha, A. G. Saminathan, P. Thirumurugan, DMEERP: A dynamic multi-hop energy efficient routing protocol for WSN, *Microprocessors and Microsystems*, Vol. 79, Article No. 103291, November, 2020.

[8] S. Kumar, N. Lal, V. K. Chaurasiya, An energy efficient IPv6 packet delivery scheme for industrial IoT over G.9959 protocol based Wireless Sensor Network (WSN), *Computer Networks*, Vol. 154, pp. 79-87, May, 2019.

[9] W. W. Huang, Y. L. Peng, J. Wen, M. Yu, Energy-efficient multi-hop hierarchical routing protocol for wireless sensor networks, *Proceedings of International Conference on Networks Security, Wireless Communications and Trusted Computing*, Wuhan, China, 2009, pp. 469-472.

[10] T. Huynh, A. Dinh-Duc, C. Tran, Delay-constrained energy-efficient cluster-based multi-hop routing in wireless sensor networks, *Journal of Communications and Networks*, Vol. 18, No. 4, pp. 580-588, August, 2016.

[11] R. Sukhchandan, S. Jain, MLBC: Multi-objective load balancing clustering technique in wireless sensor networks, *Applied Soft Computing*, Vol. 74, pp. 66-89, January, 2019.

[12] K. A. Darabkh, S. M. Odetallah, Z. Al-qudah, A. F. Khalifeh, M. M. Shurman, Energy-aware and density-based clustering and relaying protocol (EA-DB-CRP) for gathering data in wireless sensor networks, *Applied Soft Computing*, Vol. 80, pp. 154-166, July, 2019.

[13] R. Bhardwaj, D. Kumar, MOFPL: Multi-objective fractional particle lion algorithm for the energy aware routing in the WSN, *Pervasive and Mobile Computing*, Vol. 58, Article No. 101029, August, 2019.

[14] M. Masdari, S. M. Bazarchi, M. Bidaki, Analysis of secure LEACH-based clustering protocols in wireless sensor networks, *Journal of Network and Computer Applications*, Vol. 36, No. 4, pp. 1243-1260, July, 2013.

[15] A. Razaque, S. Mudigulam, K. Gavini, F. Amsaad, M. Abdulgader, G. S. Krishna, H-LEACH: Hybrid-low energy adaptive clustering hierarchy for wireless sensor networks, *IEEE Long Island Systems, Applications and Technology Conference (LISAT)*, Farmingdale, NY, USA, 2016, pp. 1-4.

[16] O. Younis, S. Fahmy, HEED: a hybrid, energy-efficient, distributed clustering approach for ad hoc sensor networks, *IEEE Transactions on Mobile Computing*, Vol. 3, No. 4, pp. 366-379, October-December, 2004.

[17] A. Razaque, M. Abdulgader, C. Joshi, F. Amsaad, M. Chauhan, P-LEACH: Energy efficient routing protocol for Wireless Sensor Networks, *IEEE Long Island Systems, Applications and Technology Conference (LISAT)*, Farmingdale, NY, USA, 2016, pp. 1-5.

[18] V. K. Kumar, A. Khunteta, Energy Efficient PEGASIS Routing Protocol for Wireless Sensor Networks, 2nd *International Conference on Micro-Electronics and*

Telecommunication Engineering (ICMETE), Ghaziabad, India, 2018, pp. 91-95.

[19] P. Maheshwari, A. K. Sharma, K. Verma, Energy efficient cluster based routing protocol for WSN using butterfly optimization algorithm and ant colony optimization, *Ad Hoc Networks*, Vol. 110, Article No. 102317, January, 2021.

[20] A. Al-Riyami, N. Zhang, J. Keane, An Adaptive Early Node Compromise Detection Scheme for Hierarchical WSNs, *IEEE Access*, Vol. 4, pp. 4183-4206, August, 2016.

[21] A. Vinitha, M. S. S. Rukmini, Dhirajsunehra, Secure and energy aware multi-hop routing protocol in WSN using Taylor-based hybrid optimization algorithm, *Journal of King Saud University - Computer and Information Sciences*, pp. 1-12, November, 2019.

[22] J. Shen, A. Wang, C. Wang, P. C. K. Hung, C. Lai, An Efficient Centroid-Based Routing Protocol for Energy Management in WSN-Assisted IoT, *IEEE Access*, Vol. 5, pp. 18469-18479, September, 2017.

[23] M. Tripathi, M. S. Gaur, V. Laxmi, R. B. Battula, Energy efficient LEACH-C protocol for Wireless Sensor Network, *Third International Conference on Computational Intelligence and Information Technology (CIIT 2013)*, Mumbai, India, 2013, pp. 402-405.

[24] S. Kaur, R. C. Gangwar, Hybrid GSTEB routing protocol using clustering and artificial bee colony optimization, *International Conference on Green Computing and Internet of Things (ICGCIoT)*, Noida, India, 2015, pp. 661-666.

Biographies

P. Saveetha received the PhD degree from Anna University, Chennai, in 2017. She is currently a Assistant professor at Nandha College of Technology, Tamilnadu, India. Her main research interests include network security, cloud computing, and sensor network. She is the member of computer society of India (CSI) and Institution of Engineers (India). She received best faculty award from IEI.

Y. Harold Robinson is currently working in School of Information Technology and Engineering, Vellore Institute of Technology, Vellore, India. He has received Ph.D degree in Information and Communication Engineering from Anna University, Chennai in the year 2016. He is having more than 15 years of experience in teaching. He has published more than 50 papers in various International Journals and presented more than 70 papers in both national and International Conferences. He has written 4 book chapters by Springer, IGI global Publication.

Vimal Shanmuganathan is working in Department of AI & DS, Ramco Institute of Technology, India. He has around Thirteen years of teaching experience, EMC certified Data science Associate and CCNA certified professional too. He holds a Ph.D in Information and Communication Engineering from Anna University, Chennai.

Seifedine Kadry received the bachelor's degree in applied mathematics from Lebanese University, in 1999, the M.S. degree in computation from Reims University, France, and EPFL, Lausanne, in 2002, the Ph.D. degree in applied statistics from Blaise Pascal University, France, in 2007, and the HDR degree from Rouen University, in 2017. He is currently an Associate Professor with the Department of Mathematics and Computer Science, Beirut Arab University, and also an ABET Program Evaluator. His research interests include education using technology, system prognostics, stochastic systems, and probability and reliability analyses.

Yunyoung Nam received the B.S., M.S., and Ph.D. degrees in computer engineering from Ajou University, Korea in 2001, 2003, and 2007 respectively. He was a Senior Researcher with the Center of Excellence in Ubiquitous System, Stony Brook University, Stony Brook, NY, USA, from 2007 to 2010, where he was a Postdoctoral Researcher, from 2009 to 2013. He was a Research Professor with Ajou University, from 2010 to 2011. He was a Postdoctoral Fellow with the Worcester Polytechnic Institute, Worcester, MA, USA, from 2013 to 2014. He was the Director of the ICT Convergence Rehabilitation Engineering Research Center, Soonchunhyang University, from 2017 to 2020. He has been the Director of the ICT Convergence Research Center, Soonchunhyang University, since 2020, where he is currently an Associate Professor with the Department of Computer Science and Engineering. His research interests include multimedia database, ubiquitous computing, image processing, pattern recognition, context-awareness, conflict resolution, wearable computing, intelligent video surveillance, cloud computing, biomedical signal processing, rehabilitation, and healthcare systems.