Global Journal of Computer Science and Technology: E
Network, Web & Security
Volume 14 Issue 8 Version 1.0 Year 2014
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 0975-4172 & Print ISSN: 0975-4350

MSEP-E: Enhanced Stable Election Protocol with Multihop Communication

By Raju Pal & Ajay K. Sharma
JIIT Noida, India

Abstract- In this paper, we have implemented cluster based novel multihop stable election protocol extended (MSEP-E) which does multihop communication between CHs and sensor nodes towards the sink. The sensor nodes and CHs which are nearer to sink send data directly to the sink while the nodes which are farther from the sink send data to its nearest hop towards the sink. Multihop communication is often required when communication range of sensor nodes is limited or number of sensor nodes is very large in the network. Evaluation and comparison reveals that MSEP-E protocol utilizes less power and attain greater network lifetime compared to stable election protocol extended (SEP-E).

Keywords: *Multihop, SEP, SEP-E, MSEP-E.*

GJCST-E Classification : *C.2.5*

MSEP-EENHANCEDSTABLEELECTIONPROTOCOLWITHMULTIHOPCOMMUNICATION

MSEP-E: Enhanced Stable Election Protocol with Multihop Communication

Raju Pal [α] & Ajay K. Sharma [σ]

Abstract- In this paper, we have implemented cluster based novel multihop stable election protocol extended (MSEP-E) which does multihop communication between CHs and sensor nodes towards the sink. The sensor nodes and CHs which are nearer to sink send data directly to the sink while the nodes which are farther from the sink send data to its nearest hop towards the sink. Multihop communication is often required when communication range of sensor nodes is limited or number of sensor nodes is very large in the network. Evaluation and comparison reveals that MSEP-E protocol utilizes less power and attain greater network lifetime compared to stable election protocol extended (SEP-E).

Keywords: Multihop, SEP, SEP-E, MSEP-E

I. Introduction

A wireless sensor network (WSN) in its simplest form can be defined as [1, 2, 3] a network of (possibly low-size and low-complex) devices denoted as nodes that can sense the environment and communicate the information gathered from the monitored field (e.g. an area or volume) through wireless links; the data is forwarded, possibly via multiple hops relaying, to a sink (sometimes denoted as controller or monitor) that can use it locally, or is connected to other networks (e.g. the Internet) through a gateway. The nodes can be stationary or moving. They can be aware of their location or not. They can be homogeneous or heterogeneous.

In cluster based approach, solely some of sensor nodes (CHs) in particular WSN are permitted to transmit sensed data towards the sink. The primary issue is that, this allows sensor nodes to sense and transmit the sensed information (in data packet form) to CHs directly, instead of routing through its neighbor and then all data is aggregated by CHs and sent over to the sink. In clustering, it is evident that the CH nodes will be over-loaded with the long-range communication to sink. Since energy dissipation during communication is proportionate to the square of distance to the sink from sending sensor node, energy of C H nodes exhausts drastically and hence the lifetime of the network get significantly reduced. One solution to this is to rotate the role of a CH among over all the sensor nodes as proposed in low-energy adaptive clustering hierarchy (LEACH) [4], power-efficient gathering in sensor information systems (PEGASIS) [5], and hybrid energy efficient distributed clustering (HEED) [6]. However, these protocols have shown poor performance in heterogeneous environment because the low-energy nodes will die more quickly than the high-energy ones. In [7], G. maragdakis, I. matta and A. bestavros proposed stable election protocol (SEP) in which every sensor node in a heterogeneous two-level hierarchical network independently elects itself as a cluster head based on its initial energy relative to that of other nodes. In [8], F. A. Aderohunmu, J. D. Deng have proposed enhanced stable election protocol (SEP-E) which introduce three level heterogeneity in SEP. Similarly, many authors have proposed new clustered routing schemes to address the issues of heterogeneity [9, 10, and 11].

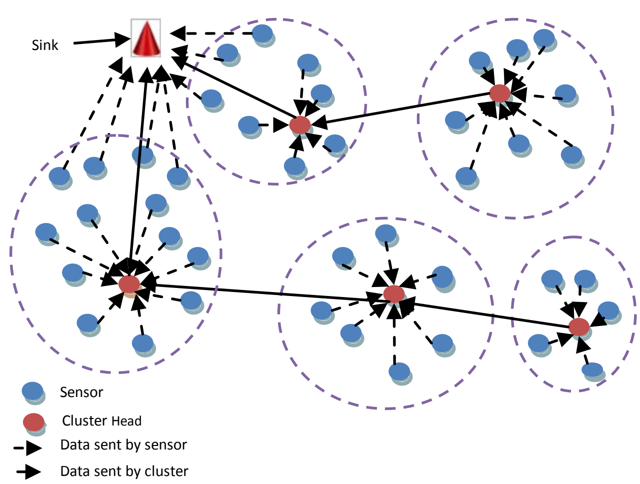

Figure 1 : Proposed multihop network

In this paper, we have further extended the SEP-E by using multihop communication between the sensor nodes. The nodes which are nearer to the sink send data directly to it rather than sending data to the CHs to reduce the load on CHs. The CH which is farthest from the sink sends data to the nearest CH towards the sink. Similarly all CHs send their data to the CH which is nearer to it compared to the sink. This communication scenario is depicted in Figure 1.

Author α: Department of Computer Science & Engineering Jaypee Institute of Information Technology Noida, India.
e-mail: raju.pal@jiit.ac.in
Author σ: Department of Computer Science & Engineering National Institute of Technology Delhi, India.

Global Journal of Computer Science and Technology (E) Volume XIV Issue VIII Version I Year 2014

The rest of the paper is organized as follows. Section 2 includes a detailed survey of the related research. Section 3 exhibits the detail of the proposed scheme. Simulation results and its discussion are presented in Sections 4 and 5. Finally, Section 6 concludes the paper.

II. Related Works

Clustering is a key technique used to extend the lifetime of a sensor network by reducing energy consumption [12]. Low Energy Adaptive Clustering Hierarchy (LEACH), a clustering based protocol that utilizes randomized rotation of local cluster base station (cluster-heads) to evenly distribute the energy load among the sensors in the network was proposed in [4]. These sensors organize themselves into clusters using a probabilistic approach to randomly elect themselves as heads in an epoch. During the setup phase, when clusters are being created, each node decides whether to become a CH for the current round. This decision is based on a predetermined fraction of nodes and the threshold T(s), which is given by the following equation:

$$(s) = \begin{cases} \frac{p_{opt}}{1-p_{opt}\times(r \bmod ({}^{1}/_{p_{opt}}))} & if\ s \in G \\ 0 & otherwise \end{cases} \qquad (1)$$

Where p_optthe predetermined percentage of CHs and r is is the count of current round. The G is the set of sensor nodes that have not been CHs in the last 1/p_opt rounds. Using this threshold, each node will be a CH at some round within 1/p_opt rounds. After 1/p_opt rounds, all nodes are once again eligible to become CHs. In this way, the energy concentration on CHs is distributed.

However, LEACH protocol is not heterogeneity-aware, in the sense that when there is an energy imbalance between these nodes in the network, the sensors die out faster than they normally should have if they were to maintain their energy uniformly. In real life situation it is difficult for the sensors to maintain their energy uniformly, thus, introducing energy imbalances. LEACH assumes that the energy usage of each node with respect to the overall energy of the system or network is homogeneous. Conventional protocols such as Minimum Transmission Energy (MTE) and Direct Transmission (DT) [13] do not also assure a balanced and uniformly use of the sensor's respective energies as the network evolves.

Stable Election Protocol (SEP), was proposed in [7], a heterogeneous aware protocol, based on weighted election probabilities of each node to become cluster head according to their respective energy. This approach ensures that the cluster head election is randomly selected and distributed based on the fraction of energy of each node assuring a uniform use of the nodes energy. In the SEP, two types of nodes (two tier in-clustering) and two level hierarchies were considered. Enhanced stable election protocol (SEP-E), was proposed in [8]. Using a heterogeneous three-tier node setting in a clustering algorithmic approach, nodes elect themselves as cluster heads based on their energy levels, retaining more uniformly distributed energy among sensor nodes.

In clustered WSNs, two typical methods are used to aggregate data. In the first method data is aggregated after it has been collected from all member nodes before the inter-cluster communication occurs and in the second method data is aggregated over each passing hop [14, 15]. In [15, 16], the authors have presented multihop routing algorithm for inter-cluster communication. This algorithm is based on multi-hop routing, which works on the principle of divide and conquer, and performs well in terms of load balance and energy efficiently as compared to LEACH.

In [17], the authors have studied LEACH scheme and proposed two new schemes (i.e., energy-LEACH and multihop LEACH). Energy-LEACH improves the CH selection method and Multihop LEACH (M-LEACH) [18] improves the communication mode from single-hop to Multihop between CH and BS. Both the schemes have better performance than LEACH scheme. In this paper we enhance the SEP-E proposed in [8], by introducing multihop communication to prolong the network lifetime and stability of the network.

III. Radio Energy and Network Model

a) *Radio energy model*

Radio Energy Model used is based on [4, 19]. Energy model for the radio hardware energy dissipation where the transmitter dissipates energy to run the radio electronics and the power amplifier, and the receiver dissipates energy to run the radio electronics. Here both the free space (d2 power loss) and the multipath fading (d4 power loss) channel models have been used, depending on the distance between the transmitter and receiver. Power control can be used to invert this loss by appropriately setting the power amplifier—if the distance is less than a threshold do, the free space model is used; otherwise, the multipath model is used. Thus, to transmit an l-bit message a distance, the radio expends

$$E_{Tx}(l,d) = \begin{Bmatrix} l.E_{elec}^{Tx} + l.\varepsilon_{amp}.d^{n} & if\ d < do \\ l.E_{elec}^{Tx} + l.\varepsilon_{amp}.d^{n} & if\ d \geq do \end{Bmatrix} \qquad (2)$$

And to receive an *l*-bit message, radio expands

$$E_{Rx}(l,d) = l.E_{elec}^{Rx} \qquad (3)$$

Where *l* is the length of the transmitted/received message in bits, *d* represents the distance over which the data is communicated and d_o is the distance threshold for swapping amplification models, which can be calculated as $d_o = \sqrt{\varepsilon_{fs}/\varepsilon_{mp}}$ As it can be seen, the transmitter expends energy to run the radio electronics and power amplifier, while the receiver only expends energy to run the radio electronics. We consider both free space (n = 2, ε_{amp} =ε_{fs}) and two-ray multipath (n = 4, ε_{amp} =ε_{mp}) models to approximate signal attenuation as a function of the distance between transmitters and receivers.

b) Network Model

Our network model is composed of three types of nodes deployed uniformly in a square region, including normal nodes, advanced nodes, and a few super nodes (Figure 2). The selection probability of each node to become a CH is weighted by the initial energy of a node relative to that of the normal node in the network. We assume each sensor node transmits sensing data to the BS through a selected CH by using multihop communication approach. All the CHs are selected periodically by different weighted probability. If CH is farther from the sink it sends the data to another CH which is nearer to the sink. Similarly each member node sends data directly to sink if they are nearer to the sink compared to its associated CH.

Assumptions:

- All the sensor nodes uniformly dispersed within a square field
- All sensor nodes and sink are stationary after the deployment.
- Multihop communication towards sink.
- A WSN consists of heterogeneous nodes in terms of node energy.
- All the sensor nodes are of equal significance.
- CHs perform data aggregation.
- The sink has enough energy in comparison with the other nodes in the network.

IV. MSEP-E

In this section we proposed an extension of enhanced stable election protocol by introducing multihop communication between the nodes. When we consider a general sensor network that may be deployed over a large region, the energy spent in the power amplifier related to distance may dominate to such an extent that using multi-hop mode may be more energy efficient than single-hop mode.

a) Setup phase

i. *CH selection mechanism*

Let us assume the case where a percentage of the population of sensor nodes is equipped with more energy resources than the normal sensor nodes in the network. Suppose E_o is the initial energy of each normal node. The energy of each advance node is then $E_o(1+\beta)$and each super node is then E_o(1+α). The total initial energy of the new heterogeneous network setting is$n * E_o(1 + m * \alpha + m_o * \beta))$ [8].

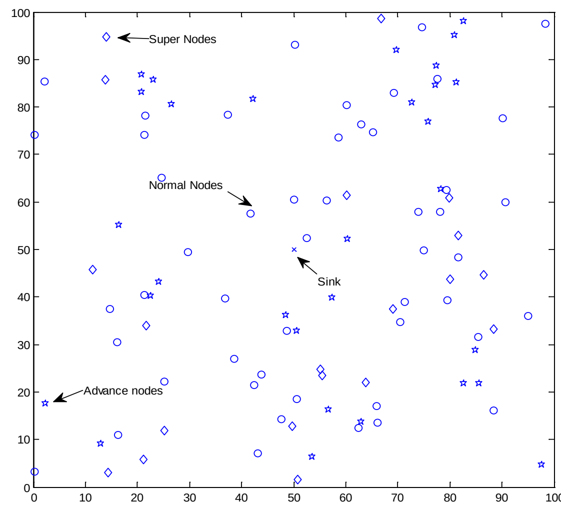

Figure 2 : Heterogeneous WSN model

Where n is the number of nodes, m is the proportion of advanced nodes to the total number of nodes n with energy more than the rest of the nodes and mo is the proportion of super nodes. So, the total energy of the system is increased by a factor of$1 + m * \alpha + m_o * \beta)$.

Our probability setting p_nrm, p_adv and p_sup and the threshold T(nrm), T(sup), $T(adv)$ for normal, advanced and super nodes respectively remains the same as in [8]. The cluster head have been selected based on the threshold value.

Once the nodes have elected themselves to be cluster heads they broadcast an advertisement message (ADV). Each non cluster-head node decides its cluster for this round by choosing the cluster head that requires minimum communication energy, based on the received signal strength of the advertisement from each cluster head. After each node decides to which cluster it belongs, it informs the cluster head by transmitting a join request message (Join-REQ) back to the cluster head. After receiving all the messages from the nodes that would like to be included into the cluster and based on the number of nodes in the cluster, the cluster head creates and announces a TDMA schedule, assigning each node a time slot when it can transmit. Each cluster communicates using different CSMA codes to reduce interference from nodes belonging to other clusters.

b) Steady phase

i. *Multihop communication mechanism*

Once the clusters are formed, each member node sends data messages in its time slot at the idle state of a frame. In order to avoid collisions during communication, a kind of CSMA model is set up. Instead of transmitting the processed data to the CH directly, every node decides whether to choose another node as the next hop or not based on above pseudo code. Similarly, each CH decides whether to transmit the data to the BS directly or to send them to the next hop. When a CH has data to send to the BS (i.e., at the end of its frame), it must sense the channel to see if anyone else is transmitting data, if so, the CH waits to transmit the data.

The pseudo code for our multihop communication scheme described as follows:

```
// non-CH nodes communication (Association to the CH)
For i=1:1:n
If sensor_node_i.type='normal' and Energy(sensor_node)>0
        If cluster_number>=1
// calculate the distance of sensor_node_i to the sink as distance1
        For c=1:cluster_number
// find out which is nearer to the node i CH or sink
Temp=min(distance1,distance_from_cluster_C);
        If (Temp<distance1)
        distance1=Temp;
        cluster=c;
        Endif
        Endfor
// Energy dissipated by sensor_node_i to send data at distance1
// if data sent to cluster c then energy dissipated by cluster c
    Packet_to_CH=n-dead-cluster_number;
    Endif
    Endif
Endfor

// CH nodes communication
For c= 1:cluster_number
Dist_to_sink_C=distance of CH c from the sink;
    For i=1:cluster_number
Dist_from_CHs=distance of CH c from other CHs;
Temp1=minimum(Dist_to_sink_C, Dist_from_CHs);
    If (Temp1< Dist_to_sink_C)
    Dist_to_sink_C=Temp1
    // CH c is nearer then sink at Dist_to_sink_C;
    Endif
    Endfor
// Energy disspated by CH c in sending data at distance Dist_to_sink_C;
// if CH directly send data to sink then
Packets_to_BS= Packets_to_BS+1;
Endfor
```

When the sensor nodes are deployed in regions of dense vegetation or uneven terrain, it may be beneficial to use multi-hop communication among the nodes in the cluster to reach the cluster head. As it is possible for nodes to remain disconnected from the network due to a cluster head not being in range, each node is able to request another connected node to become a cluster head. This occurs after a timeout period and is done through a normal advertisement message.

V. Performance Matrices

The following matrices are used to evaluate the performance of MSEP-E and SEP-E in different network scenarios.

a) *Network lifetime*

Network lifetime strongly depends on the lifetimes of single nodes that constitute the WSNs. The lifetime of the network basically depends on two major factors: (i) how much energy it consumes over rounds and (ii) how much energy is available for its use *(Total Residual Energy*). The definition of the network lifetime is determined by the kind of service it provides. In many cases, it is necessary that all the sensor nodes stay alive as long as possible. Since the network performance decreases as soon as a single node dies. In this scenario, it is important to know when the first node dies (FND). Furthermore, sensor nodes can be placed in proximity to each other. Therefore, adjacent nodes could record the same or identical data in the network. Hence, the death of a single or few nodes does not affect the performance of the network. In this case, the metric half node dies (HND) denotes an estimated value for the half life period of a network. Finally, the metric last node dies (LND) defines network lifetime as the time until all nodes have been drained of their battery energy. This metric is very rarely used in clustering algorithms. Since more than one node is necessary to perform the clustering technique. Hence, in this paper, we use two metrics (i.e., FND and HND) for the evaluation of different algorithms

Stability: This is the time interval when the first node of the network dies.

b) *Throughput*

We measure the total rate of data sent over the network, the rate of data sent from cluster heads to the sink as well as the rate of data sent from the nodes to their cluster heads.

VI. Simulation Results and Discussion

In this section, we evaluate the performance of MSEP-E via MATLAB simulations. We compare it with SEP-E in the same heterogeneous setting, where the extra initial energy of advanced nodes and super nodes is uniformly distributed over the sensor field. We use $100m \times 100m$ region of 100 sensor nodes (Figure 2). We denote a normal node with “o”, an advanced node with “*”, a super node with◊”, and the BS with “×”. The simulation parameters are mentioned in Table 1.

Table 1 : Simulation parameters

Description	Parameters	Value
Network Size	M×M	100×100 m^2
Location of Sink	BS	(50,50)
Number of Nodes	n	100
Initial Energy of Nodes	E_o	0.1 J
Proportion of advanced nodes	m	0.2
Proportion of super nodes among advanced nodes	m_0	0.3
Energy factor for super nodes	α	2
Energy factor for advanced nodes	β	1
Energy dissipated per bit	E_{elec}	50 nJ/bit
Transmit amplifier if $dBS \le d0$	E_{fs}	10 pJ/bit/m^2
Transmit amplifier if $dBS \ge d0$	E_{mp}	0.0013 pJ/bit/m^4
Data aggregation energy by CH	E_{DA}	5 nJ/bit/message
Size of Data Packet		4000 bits

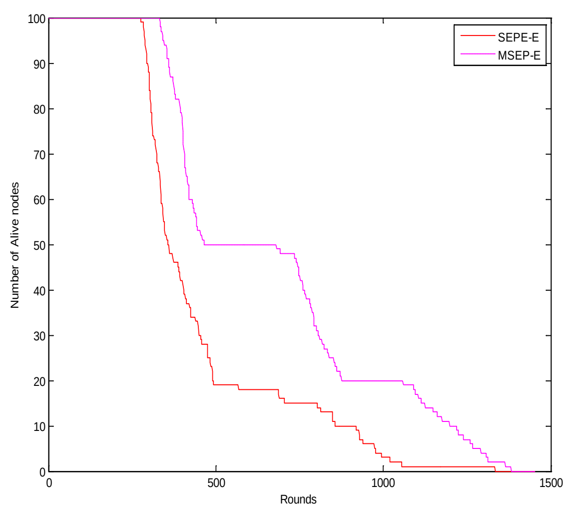

Figure 3 : Number of Alive nodes per round

fter a node drain its energy it dies, and it cannot communicate with other nodes any more. We run the simulation on above setting and found that MSEP-E outperforms the existing SEP-E protocol. Figure 3 clearly indicate that MSEP-E prolong the lifetime of the network. Since SEP-E adopts single-hop communication for both non-CH and CH communication, it shows poor performance in large network areas because all the sensor nodes have to consume more battery energy to perform the long haul communication whereas MSEP-E adopts multi-hop communication, hence consumption of battery energy is less.

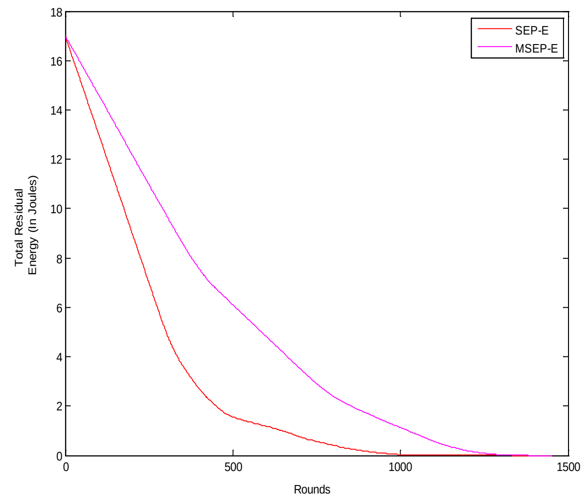

Figure 4 : Total Residual Energy per round

Table 2 : comparison of residual energy

Rounds	Total Energy (in joules)	
	MSEP-E	SEP-E
1	17	17
200	12.1954	9.0296
500	6.1238	1.5638
700	3.5419	0.7657
1000	1.1374	0.0316
1200	0.1908	0.0061

The comparison of total residual energy on different rounds is shown in Table 2 and Figure 4 demonstrates the overall increase in total residual energy per round. Initially all nodes have 0.1 joule (J) of energy and total energy of the network is 17 J. After 200 rounds total residual energy of the network will be 12.7954 J and 9.0296 J for MSEP-E and SEP-E respectively. This indicate that SEP-E consume more energy approx 8 J then MSEP-E (approx 5J) after 200 rounds. Similarly, Table 2 depicts the residual energy of both protocols after 500, 1000 and 1200 rounds. Hence, the energy consumption is very less when we use multihop communication.

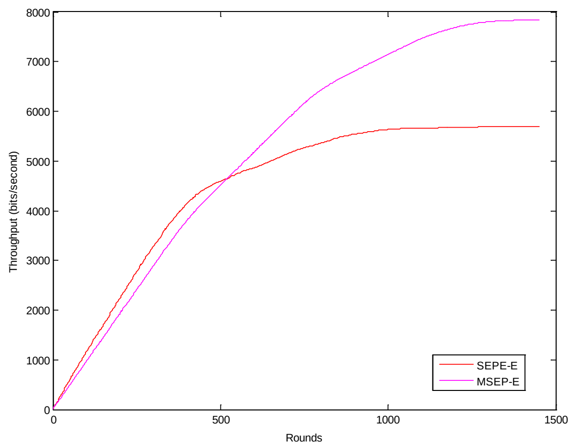

Figure 5 : Throughput of the network

Figure 5 illustrates the throughput of the network. The amount of data messages received at the sink will increase over number of rounds as compared with SEP-E since the lifetime of the network increased and we have more number of alive nodes. Hence the throughput of MSEP-E is increased by 3.5%.

Table 3 : Comparison of dead nodes

% Nodes	Number of rounds	
	SEP-E	MSEP-E
1%	277	333
25%	311	401
50%	360	680
100%	1335	1383

Table 3 and Figure 6 shows that stability of the network is increased by 20%. In SEP-E first node died (FND) at 277th round while in MSEP-E first node died at 333th round.

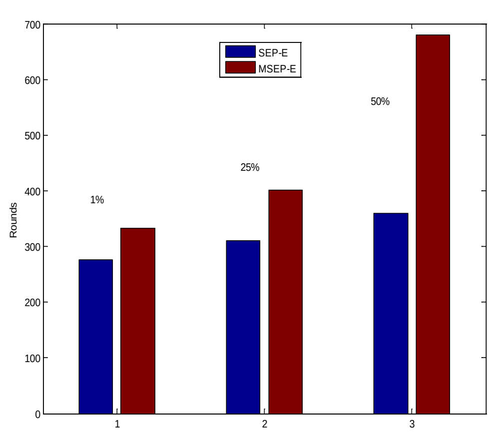

Figure 6 : Comparison of % node dies

The half life of the network also increased by 88%. The 50% of the nodes died (HND) at 360th round and 680th round for SEP-E and MSEP-E respectively. The last node of the network (LND) died at 1135th round and 1383th round for SEP-E and MSEP-E respectively. This shows that overall performance and lifetime of the network significantly increased in the case of MSEP-E.

VII. Conclusion

It has thus, been concluded that MSEP-E protocol consumes less energy as it uses energy minimizing techniques like multihop communication, clustering and data aggregation. The multi-hop communication approach is adopted for both non cluster head and cluster head nodes communication towards the sink. Simulation results indicate that MSEP-E can greatly balance energy consumption of an entire network and thus extends the network lifetime and stability of WSN. MSEP-E can be considered for applications such as health monitoring where energy utilization is critical.

References Références Referencias

1. C. Chong & S. P. Kumar, "Sensor networks: evolution, opportunities, and challenges". *Proceedings of IEEE, 91* (8), pp. 1247 – 1256, (2003).
2. D. Culler, D. Estrin, & M. Srivastava, "Overview of sensor networks". *IEEE Computer* , 37 (8) , pp. 41 – 49, (2004).
3. I. F. Akyildiz, W. Su, Sankarasubramaniam & E. Cayirci, "A survey on sensor networks" . IEEE *Communications Magazine* , 4 0 (8) , pp. 102 – 114, (2002).
4. W. B. Heinzelman, A. P. Chandrakasan, and H. Balakrishnan, "An application-specific protocol architecture for wireless microsensor networks," *IEEE Transactions on Wireless Communications*, vol. 1, no. 4, pp. 660–670, (2002).
5. S. Lindsey and C. S. Raghavendra, "PEGASIS: power-efficient gathering in sensor information systems," in Proceedings of the *IEEE Aerospace Conference*, vol. 3, pp. 125–1130, (2002).
6. O. Younis and 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, (2004).
7. G. Smaragdakis, I. Matta, and A. Bestavros, "SEP: a stable election protocol for clustered heterogeneous wireless sensor networks," in *Proceedings of the 2nd International Workshop on Sensor and Actor Network Protocols and Applications (SANPA'04)*, pp. 251–261, Boston, Mass, USA, (2004).

8. F. A. Aderohunmu, J D. Deng, " An Enhanced Stabel Election Protocol (SEP) for Clustered Heterogeneous WSN", Discussion Paper Series, No. 2009/07, October 2009, ISSN: 1177-455X, Department of Information Science, University of Ontago, (2010).
9. D. Kumar, T. C. Aseri, andR. B. Patel, "EEHC: energy efficient heterogeneous clustered scheme for wireless sensor networks," *Computer Communications*, vol. 32, no. 4, pp. 662–667, (2009).
10. V. Mhatre and C. Rosenberg, "Homogeneous vs heterogeneous clustered sensor networks: a comparative study," in *Proceedings of the IEEE International Conference on Communications (ICC '04*), vol. 27, pp. 3646–3651, June, (2004).
11. V. Mhatre and C. Rosenberg, "Design guidelines for wireless sensor networks: communication, clustering and aggregation," *Ad Hoc Networks,* vol. 2, no. 1, pp. 45–63, (2004).
12. M. Younis, M.Youssef, and K. Arisha, "Energyaware management in clusterbased sensor networks". Computer Networks. 43 (5): pp 649–668, (2003).
13. T. J. Shepard, "A channel access scheme for large dense packet radio networks," in *Proccedings of ACM SIGCOMM*, pp. 219–230, September (1996).
14. C. Stefano, N. Chilamkurti, and S. Zeadally, "A novel centralized clustering algorithm for energy efficient wireless sensor networks," *International Journal of Autonomous and Adaptive Communications Systems,* vol. 1, no. 2, pp. 242– 61, (2008).
15. Nauman and I. Awan, "Multi-hop routing algorithm for inter cluster head communication," in *Proceedings of 22nd UK Performance Engineering Workshop*, pp. 24–31, Bournemouth, UK, (2006).
16. N. Israr and I. U. Awan, "Multilayer cluster based energy efficient routing protocol for wireless sensor networks," *International Journal of Distributed Sensor Networks*, vol. 4, no. 2, pp. 176–193, (2008).
17. F. Xianging and S. Yulin, "Improvement on LEACH protocol of wireless sensor networks," in *Proceeding of International Conference on Sensor Technologies and Applications,* pp. 260– 264, (2007).
18. Rajashree.V.Biradar , Dr. S. R. Sawant , Dr. R. R. Mudholkar, Dr. V.C .Patil , Multihop Routing In Self-Organizing Wireless Sensor Networks, International Journal of Computer Science Issues, Vol. 8, Issue 1, January (2011).
19. W.Heinzelman, A. Chandrakasan, and H. Balakrishnan, "Energy-efficient communication protocol for wireless sensor networks," in the Proceeding of the Hawaii International Conference System Sciences, Hawaii, (2000).

This page is intentionally left blank