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Impact of Various Performance Parameters on Distributed Protocols in Wireless Sensor Networks

Sukhkirandeep Kaur[1*], R.N Mir[2]

[1]Dept. of Computer Science and Engineering, National Institute of Technology, Srinagar, India
[2]Dept. of Computer Science and Engineering, National Institute of Technology, Srinagar, India

*Corresponding Author: kirangill0189@gmail.com

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***Abstract*—** Wireless Sensor Network (WSN) consists of small sensor nodes that cooperate with each other to send sensed data to the Base-Station (BS). Several challenges are imposed in WSN with energy consumption being the most important. Clustering improves energy efficiency in WSN by sending data through CHs in one-hop and multi-hop communication. Distributed clustering methods are more efficient as compared to centralized clustering methods in terms of energy efficiency and the choice of the optimal parameter value is important in distributed clustering as it acts as a significant part in preserving energy. Individual parameters like the position of BS, the optimal number of CHs, heterogeneity factor etc. impact the performance in distributed protocols. This work evaluates the performance of well-known distributed protocols by varying the values of different parameters to study their effect on network performance. Simulations are performed and results are analyzed to check the effect of performance parameters.

***Keywords*—**Wireless Sensor Network (WSN), Clustering, Distributed protocols, Centralized protocols, Stability

I. INTRODUCTION

A Wireless Sensor Network (WSN) is a network of small, interconnected sensor nodes that sense physical phenomenon and send the sensed data to a BS through single or multi-hop communication. WSN has gained a lot of popularity due to its vast use in many applications that includes monitoring and surveillance, military applications etc. Most of these applications are deployed in remote areas where human intervention is not possible like forest monitoring etc. Applicability of these applications in such areas leads to several issues such as energy efficiency, network lifetime, scalability, fault tolerance etc. Several approaches are designed to overcome these challenges like clustering, load balancing, Quality of Service (QoS). Clustering is very popular approach in WSN to improve the energy efficiency as cluster heads (CHs) collect the data from sensor nodes and send this data through other CHs to BS. This reduces the problem of energy depletion as sensor nodes do not have to directly transmit the data. They send data to their CHs in short distances and CHs send the received data to other nearby CHs on the way to BS. Scalability is also achieved with the help of clustering and to manage energy consumption, CH role is rotated through the network operation.

Clustering algorithms can be centralized or distributed. A centralized method involves the sink or CH to acquire global information and the decisions regarding any change in the network is taken by them [1]. The central authority, BS or sink controls the clustering process. Nodes send their information to a central controller and based on that information, clusters are formed. The main drawback of this approach is the information exchange. A lot of information is exchanged with the central controller that increases traffic in the network. Scalability is also an issue due to centralized information exchange and this information needs to be updated with time because over a period of time, a node's energy level changes or it may completely run out of energy leading to network hole. Different centralized algorithms are LEACH-C [2], A Regional Centralized Clustering Routing Algorithm for Wireless Sensor Networks" [3], "Energy efficient Dynamic Clustering (EEDC)" [4].

Distributed algorithms overcome the problems faced in centralized algorithms by selecting CHs in a distributed manner. Nodes do not send their information to a central controller, rather they exchange information among neighboring nodes and take a decision of CH selection in a distributed manner. In Distributed algorithms, CH can be selected based on a probability value or by using weighted metric. Based on several parameters, like residual energy, Distance to BS or several other parameters, a weighted metric is designed for each node and based on this weighted metric, a CH is selected. In distributed algorithms, amount of data exchange between sink and nodes is reduced and as nodes themselves take a decision regarding clustering

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approach and scalability is enhanced. Distributed algorithms can be probabilistic where, a probability value is assigned before clustering process takes place. Each node assigns its role by itself and based on some probability criterion, a CH is selected. In this work, various probabilistic algorithms are discussed and are compared based on different performance parameters.

In this paper, our aim is to study the effect of different parameters on the behavior of various distributed protocols for WSNs. The behavior of different protocols is analyzed through simulations for different parameters like BS position, network area, heterogeneity factor etc.

Rest of paper is organized as follows: section II discusses energy model, the detailed description of distributed protocols is discussed in section III. Section IV, discusses the results followed by the conclusion.

II. ENERGY MODEL

Energy consumption in sensor nodes takes place in form of sensing, processing and communication. A major source of energy consumption in WSN is transceiver energy i.e. energy consumed while transmitting and receiving data. WSN can also be viewed as an undirected graph G = <V, E>, where V represents the vertices i.e. sensor nodes and E represents the edges i.e. links between nodes. Two nodes n1 and n2 are said to be connected if there exists a link between them i.e. E(n1, n2). A link exists between two nodes if the Euclidean distance between nodes is equal or less than their transmission range. . The energy model for a sensor network is proposed by Heinzelman et. al. [5].

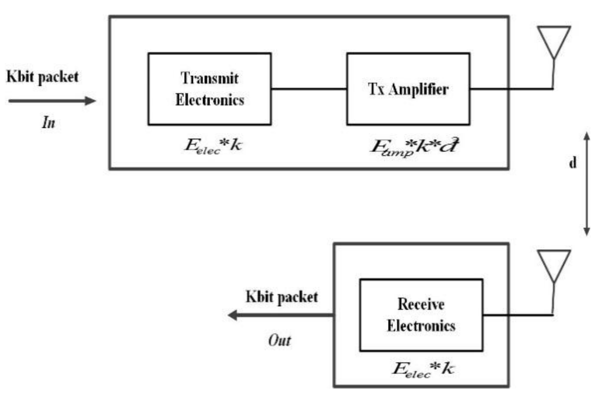

Figure 1. Energy Model

According to this model, energy consumed while transmitting and receiving data over distance d is represented as :

$$E_{tn}=e_{elec}* \mathrm{k} + e_{amp}* \mathrm{k} *d^n \quad (1)$$

$$E_r = e_{elec}* \mathrm{k} \quad (2)$$

where e_{tn} is transmission energy, e_{elec} is the energy of electronic circuits, e_{amp} is the amplification energy, E_r is energy consumed while receiving data, k represents bits and d is the distance.

III. DISTRIBUTED PROTOCOLS

III.I LEACH

Low Energy Adaptive Clustering Hierarchy (LEACH) [6] is the first clustering protocol developed for homogeneous WSNs. The protocol works in two phases i.e. set up phase and steady-state phase. The network operates in rounds at each round, a node decides whether to become a CH based on pre-determined threshold value T(s). A node chooses a random number between 0 and 1. A node is chosen as CH if the number is less than the following threshold:

$$\mathrm{T(n)} = \begin{cases} \frac{\mathrm{r}}{1-p_i(\mathrm{r} \bmod \frac{1}{p_i})} & \text{if n€G} \\ 0 & \text{otherwise} \end{cases} \quad (3)$$

p_i is the weighted probability of node to become a CH, r is the current round, and G is the set of nodes that have not been elected CHs in the last 1/P rounds. In case of LEACH, every node become a CH every $n_i = \frac{1}{p_i}$ rounds.

After a CH is selected, it broadcast announcements to other nodes and the nodes, based on signal strength joins the cluster. A CH after receiving request messages creates a TDMA schedule and the data transmission takes place. In LEACH. CHs are not uniformly distributed. This problem in LEACH is further resolved in LEACH-C [2] and fixed LEACH [7].

III.II DEEC

Distributed Energy-Efficient Clustering (DEEC) [7] protocol, considers 2-level and multi-level heterogeneity. It considers normal nodes and high energy nodes. Initially, the high energy nodes are equipped with an initial energy of E0 * (1 + a) which is a times more energy than the lower bound E0 of the energy interval. E0 is the energy of normal nodes and in this network, the energy distribution is not uniform so, the average energy of round r can be obtained as:

$$\bar{E}(r) = \frac{1}{N}\sum_{i=1}^{N} E_i(r) \quad (4)$$

and total rounds can be estimated as

$$\mathrm{R} = \frac{E_{total}}{E_{round}} \quad (5)$$

where, E_{round} is energy dissipated in the single round and is given by when CHs directly transmit to BS

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$$E_{round} = L(2NE_{elec} + NE_{DA} + k\epsilon_{mp}d_{toBS}^4 + N\epsilon_{fs}d_{CH}^2) \quad (6)$$

and p_i i.e. the probability of CH selection is given by:

$$p_i = p_{opt}\frac{E_i(r)}{\overline{E(r)}}, \quad (7)$$

For normal, advanced and super nodes, p_i *can be* evaluated as:

$$p_i = \frac{p_{opt\,E_i(r)}}{(1+am)\bar{E}(r)}\text{, for normal nodes} \quad (8)$$

$$p_i = \frac{p_{opt\,(1+a)E_i(r)}}{(1+am)\bar{E}(r)}\text{, for advanced nodes} \quad (9)$$

and the threshold for normal, super and advanced nodes is given by:

$$T(n) = \begin{cases} \frac{p_i}{1-p_i\left(r \bmod \frac{1}{p_i}\right)} & \text{if } p_i \text{€} G \\ \frac{p_i}{1-p_i\left(r \bmod \frac{1}{p_i}\right)} & \text{if } p_i \text{€} G' \\ 0 & otherwise \end{cases} \quad (10)$$

G is a set of sensor nodes that have not been selected CH in last 1/pi rounds and G' is a set of advanced nodes.

III.III SEP

Stable Election Protocol (SEP) [8] is a heterogeneous protocol where heterogeneity is defined in terms of energy by normal and super nodes. Nodes are uniformly distributed and the main aim of this protocol is to increase the stability period. CHs in SEP is selected based on residual energy. It is assumed that sink is located in the center of the field and the distance of any node to its CH and sink is less than d_o and total energy of the network is given by:

$$E_{round} = L(2NE_{elec} + NE_{DA} + \epsilon_{fs}(kd_{toBS}^2 + nd_{CH}^2) \quad (11)$$

Comparing with LEACH, SEP provides efficient results in terms of first node death time, stability, and throughput. The efficiency of SEP decreases when most of the nodes are deployed far from BS that results in more energy consumption.

III.IV Z-SEP

Zonal Stable Election protocol (ZSEP) is a heterogeneous protocol that is an extension of SEP. In ZSEP, the whole network is divided into zones based on distance to BS. Normal nodes are deployed near BS and advanced nodes in zones farther from BS. Normal nodes directly transmit data to BS whereas advanced nodes transmit data through clustering process. The threshold for CH selection is same as defined in LEACH. The probability for advance nodes to become a CH is same as given by SEP

$$Padv = Popt/1 + (\alpha.m) \times (1+\alpha) \quad (12)$$

Based on RSSI, nodes join selected CH and clusters are formed and transmit data to BS via TDMA scheduling. Compared to SEP and LEACH, this protocol performs better in terms of stability and throughput.

IV. RESULTS AND DISCUSSIONS

In this section, the performance of different distributed protocols is evaluated by extensive simulations. In the network, 100 nodes are deployed and stability period for LEACH, DEEC, SEP, ZSEP is compared based on predefined CH%(P_{opt}), Heterogeneity factor(a_{max}), for different network area and BS configurations. Stability period is defined as the time when the first node run out of energy.

Table 1: Simulation Parameters

Parameter	Value
Network size	100*100
Number of nodes	100
Eo	0.5 J
Eelec	50 nJ/bit
ϵ_{fs}	10 pj/bit/m^2
ϵ_{mp}	0.0013 pj/bit/m^4

IV.I Network area

To evaluate scalability, DEEC, SEP, ZSEP, LEACH are simulated for different network configurations. 100 nodes are deployed in 50*50, 100*100, 150*150 area. For 50*50 and 100*100, ZSEP outperforms other protocols. Performance of DEEC and SEP remains constant for all network configurations. For 150*150 area, stability period of ZSEP decreases because when network area increases, the area where nodes directly transmit also increases that in turn increases energy consumption as nodes transmit over longer distance to BS. The effect of different network area configurations is illustrated in Fig.2.

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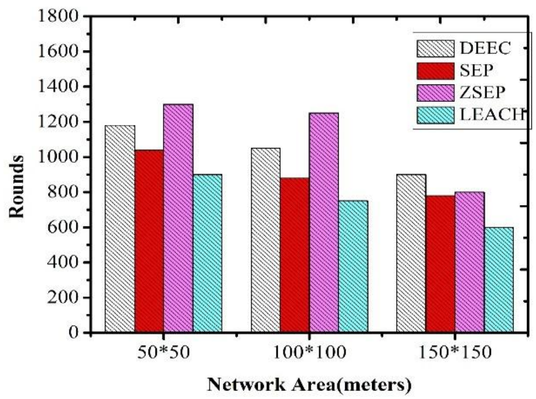

Figure 2. The effect of different network configurations on stability period.

IV.II BS position

Stability of the mentioned protocols is compared for different BS positions. BS is placed at (0, 0) i.e. upper left corner, (50, 50) at the center of the network and (100*100) i.e. at the end of the network. ZSEP has the highest stability period when BS is placed at the center of the network. For other BS placements, stability period of ZSEP is very low due to the reason that we followed the same configuration as mentioned in the original work, we do not make any changes in the configurations. DEEC has highest stability period for (0, 0) and (100,100) among others. Fig. 3 shows the effect of BS position on stability period.

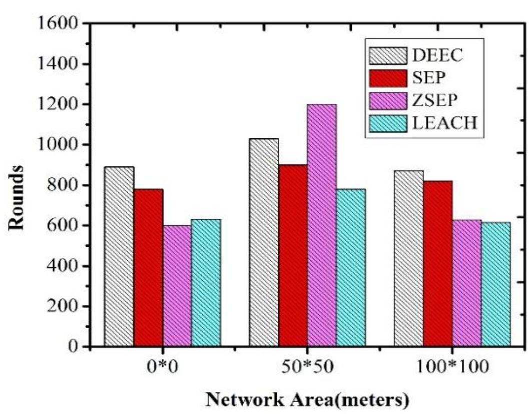

Figure 3. The effect of BS position on stability period.

IV.III Optimal number of CHs

To study the effect of predefined CH%, we varied the value of P_{opt} from 0.03 to 0.9 with an increment of 0.01. Fig. 4, shows the effect of P_{opt} on stability period.

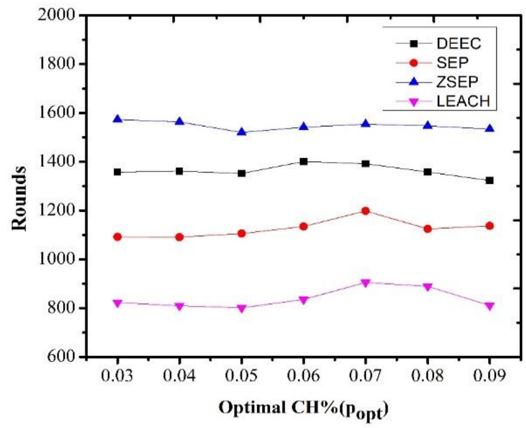

Figure 4. The effect of predefined percentage of cluster heads on stability period.

For P_{opt}=0, no CH is selected and sensor nodes directly send data to BS. For, $P_{opt} = 1.0$, all nodes can be selected as CH. At 0.06 & 0.07, increase in stability period is observed for all protocols. This states that for P_{opt}, in range of 0.06 - 0.1, efficient results can be obtained in terms of stability. For different values of P_{opt}, ZSEP has higher stability period compared to other protocols and LEACH has lowest the stability .

IV.V Heterogeneity factor ($\boldsymbol{a_{max}}$)

Effect of energy heterogeneity on stability period can be observed from Fig. 5. Value of a_{max} is varied from 1 to 5 with an increment of one. When $a_{max} = 0$, then network is a homogeneous one and the energy consumption is uniform. For different values of a_{max}, ZSEP has constant stability period compared to other protocols. Increasing a_{max} results in drop in stability period of DEEC, SEP and LEACH. After increasing a_{max} to a certain value, drop in stability period is observed.

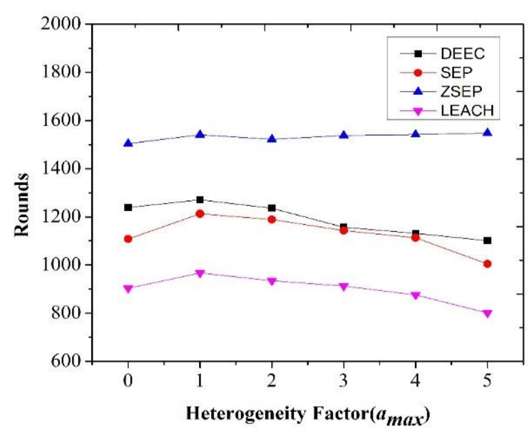

Figure 5. The effect of heterogeneity factor on stability period.

V. CONCLUSION

This work evaluates the performance of well-known distributed protocols by varying different performance parameters. Position of BS, optimal number of CHs, Heterogeneity factor plays an important role and selection of suitable parameter value is very important for the performance of the network. Network was simulated for DEEC, SEP, ZSEP and LEACH by varying the values of different parameters to evaluate their effect on stability period. For different network area configurations and BS positions, DEEC has highest stability while for heterogeneity factor and optimal cluster head percentage, ZSEP outperforms other protocols.

REFERENCES

[1] S. Kaur and R. N. Mir. "*Clustering in Wireless Sensor Networks-A Survey*" International Journal of Computer Network and Information Security, Vol.8, No.6, 2016

[2] R.M.B. Hani and A.A. Ijjeh, "*A survey on leach based energy aware protocols for wireless sensor networks*", Journal of communication, Vol. 8, 2013.

[3] T. Gao, R. Jin, "*A regional centralized clustering routing algorithm for wireless sensor networks*", IEEE, 2008.

[4] K. Padmanabhan, P. Kamalakkannan, "*Energy-efficient Dynamic Clustering Protocol for Wireless Sensor Networks*", International Journal of Computer Applications, Vol.38, No.11, 2012.

[5] N. Kamyabpour, D.B. Hoang, "*Modeling overall energy consumption in wireless sensor networks*", 11th International Conference on Parallel and Distributed Computing, Applications and Technologies, PDCAT-10, pp. 8–11, 2010.

[6] W.Heinzelman, A.Chandrakasan, and H. Balakrishnan, "*Energy-Efficient Communication Protocols for Wireless Microsensor Networks*", Proceedings of the 33rd Hawaaian International Conference on Systems Science (HICSS), 2000.

[7] W. R. Heinzelman, A. Chandrakasan, and H. Balakrishnan,"*An application specific protocol architecture for wireless microsensor networks*" IEEE Transactions on Wireless Communications, Vol. 4,pp. 660-670, 2002.

[8] L. Qing, Q. Zhu, M. Wang, "*Design of a distributed energy-efficient clustering algorithm for heterogeneous wireless sensor networks*" ELSEVIER, Computer Communications, Vol. 29, pp 2230-2237, 2006.

[9] S. Georgios, I. Matta, and A. Bestavros. "*SEP: A stable election protocol for clustered heterogeneous wireless sensor networks*". Boston University Computer Science Department, 2004.

[10] S. Faisal, "*Z-SEP: Zonal-stable election protocol for wireless sensor networks*." arXiv preprint arXiv: 1303.5364, 2013.

Authors Profile

Sukhkirandeep Kaur is a research scholar in the Department of Computer Science & Engineering at NIT Srinagar, INDIA. She received her B.Tech in Computer Science & Engineering from Punjabi University, Patiala(India) in 2010 and M.Tech in Computer Science & Engineering from Lovely Professional University, Jalandhar(India) in 2012. Her research interests include Routing and Clustering in Wireless Sensor Networks.

Roohie Naaz Mir is a professor in the Department of Computer Science & Engineering at NIT Srinagar, INDIA. She received B.E. (Hons) in Electrical Engineering from University of Kashmir (India) in 1985, M.E. in Computer Science & Engineering from IISc Bangalore (India) in 1990 and Ph.D from University of Kashmir, (India) in 2005. She is a Fellow of IEI and IETE India, senior member of IEEE and a member of IACSIT and IAENG. She is the author of many scientific publications in international journals and conferences. Her current research interests include reconfigurable computing and architecture, mobile and pervasive computing, security and routing in wireless adhoc and sensor networks.