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Partition based Multi-chain Clustering Protocol for Wireless Sensor Networks

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Abstract: Wireless sensor network is a network of tiny and small sensors. Due to limited size, it has limited energy supply and called a energy constraint network. It is required to design network in such a way so that it can pertain long time. To enhance network lifetime routing play a crucial role in it. Hierarchical routing is best to conserve more energy for data transmission. LEACH is the first hierarchical routing protocol for wireless sensor networks. However, it lacks in various scenarios of real deployment of the networks. In this paper, a Partition based Multi-Chain Clustering (PMCC) protocol for wireless sensor networks has been proposed to extend network lifetime. The objective of this work is to prolong the network lifetime by logically dividing the sensing field into a number of zones, which a multi-chain structure in the cluster is used for data forwarding and minimum spanning tree algorithm is adopted for communication among cluster heads. The simulation results shows that the use of proposed protocol offers significant improvement over existing protocols in extending network lifetime.

keywords: Wireless sensor network, multi-chain, residual energy, network lifetime, load balancing.

I. INTRODUCTION

In today's world of computing, information gathering is a fast growing and challenging field in the different area such as inhospitable and low-maintenance areas where conventional approaches prove to be very costly [1]. Sensors provide a low-priced and straightforward solution to these applications. These physical devices are small in size that is capable of gathering environment information like heat, light or motion of an object. Sensors are deploying in a simple model in the area of interest to monitor events and gather data about the surroundings. Networking of these unattended sensors is expected to have a major impact on the effectiveness of many military and civil applications, such as combat field observation, security and adversity management. Sensor nodes in such systems are typically throwaway and expected to last until their energy drain. Therefore, for sensor networks power is a very crucial resource and for the duration of a particular mission. It has to be managed wisely to extend the life of the sensor nodes. The sensor networks pursue the model of a base station, where sensors relay streams of data to the base station either like periodically or action based. The control node/ base station may be statically allocated in the surrounding area of the sensor, or it may be mobile so that it can move around the field and collect data from the network. In either case, the base station cannot be reached strongly by all the sensor nodes in the network. The nodes that are located far from the base station will consume more energy to transmit data than other nodes and therefore will die sooner [2].
In Wireless Sensor Network (WSN), it consists of a potentially large number of resource constrained sensor nodes. The sensor node has a battery and a low-end processor, a limited amount of memory, and a low power communication module capable of short range wireless communication [3]. As sensor nodes are deployed randomly and have very limited battery power, it is impossible to recharge the dead batteries. That's why battery power is considered as a limited resource in WSN and should be efficiently used. Sensor node consumes battery in sensing data, receiving data, sending data and processing data [4]. A sensor node does not have enough power to send the information directly to the far base station. Therefore, along with sensing data the sensor node act as a router to promulgate the data of its neighbor. The sensor nodes can be grouped into small clusters in a large sensor network. Each cluster has a cluster head to coordinate the nodes in the cluster [5]. However, in cluster based network the nodes transmit it's data to cluster heads directly within cluster which consume much energy of the node [6]. In multi-hop routing, the sensor node die early if low energy nodes becomes the intermediate node. Hence, all intermediate nodes die early and there will be no data transmission. This problem can be mitigated by combining the multi-hop transmission approach with cluster based network.
In this paper, a Partition based Multi-Chain Clustering (PMCC) protocol is proposed for wireless sensor networks which provides an energy efficient network that retain for long time. In this protocol, Initially, sensing field logically divided into a number of zones. In each zone multi-chain structure are formed for data forwarding. The inter zone communication follow the minimum spanning tree algorithm to forward data to base station. In order to reduce

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the number of forwarding packet and lower energy consumption, cluster heads are selected based on priority value computed via remaining energy and distance to base station. This approach is shown to be an effective solution for load balancing and extending network lifetime in large multi-hop networks.
The rest of the paper is organized as follows. Section II discusses the previous routing protocols. Section III describes the proposed approach. Section IV provides an overview of simulation and results. Section V briefly summarized the conclusion and future work.

II. Related Work

Recently, a large number of multi-hop communication techniques and algorithms have been proposed for WSNs, and simultaneously many studies have been done to analyze existing routing techniques and algorithms. In [2], authors select the cluster member by considering the maximum transmission power of the nodes; its membership depends on the communication cost. In this method, backup recovery is not to be considered. In paper [7], author improves the choice of the cluster member by using comprehensive weight value composed of distance between the cluster head and the member and the residual energy. To avoiding the load imbalance, it uses optimization threshold value too. For developing the balanced cluster, the algorithm considers load equalization. In this paper [8], for intra and inter-cluster communication layered approach is used. This algorithm considers similar network. In this paper [9], fairly distributed cluster heads increase the network lifetime. The cluster heads used the transmission range reconfiguration to balance the clusters that based on the number of general nodes in the cluster and the number of cluster heads. The algorithm provides effective data aggregation. In this paper [10], for packet forwarding uses optimal scheduling algorithm in which determines the time slot for sending the packets for the nodes. The algorithm provides uniform packet loss probability for all the nodes. The algorithm uses balanced cost objective function for optimum scheduling. In this research [11], for improving data accuracy and use of bandwidth WSN to increase network lifetime, pseudo-sink protocol is introduced. In this paper [12], handles the hot point problems which use the pruning mechanism in the cluster to balance the load in the network. Evaluation function in the algorithm is based on pruning mechanism and uses nodes location, residual energy and count of cluster nodes as its parameter to find its cost. In this paper [13], by dividing the sensor network nodes into subsets, the algorithm consider sensing coverage & network connectivity. To ensure the network connectivity, it turns on some extra nodes in each subset. The problem with this approach is to find the existence of critical nodes. These nodes may be on all the time and if these nodes die the network will be partitioned In this paper [14], provides possible in- network method for adaptive distributed control of energy consumption. In this, some other methodologies like a market-based algorithm or game theoretic algorithm are used. The algorithm assumes complete connectivity.
In this paper [15], density as a key parameter, the load balancing algorithm is proposed for cluster heads in wireless sensor networks by considering the traffic load. It is supposed i.e. the traffic load supplemented by entire sensor nodes is same, which is the special case of this algorithm. It is an NP-hard method. It uses centralized approach and assumes that each node is aware of the network. In this paper [16], load balanced group clustering to balance the battery power by implementing dynamic route calculation according to the condition of energy distribution in the network. In this paper [17], in this paper fuzzy based approach is used in distributing database for load balancing on sensor network that extends the lifetime of the network. A new approach vertical partitioning algorithm for distributing a database on sensors is used in this paper. In this approach, first clusters are formed and then distribute partitions on clusters. In this paper [18], a new clustering protocol of load balancing which isolates the entire network to the virtual circle with variable radiuses is proposed. This protocol used in such a fashion that radius of every virtual circle and the size of every cluster will rise with the augmenting distance from the base station, in such a way that cluster size of every circle would be distinct with the clusters of the other circles.In this study, the prospective protocol, network coverage after the initial node dead, first node dead, decreases harmonically and uniformly. It also raised network lifetime incomparably in such a way that the lifetime of the network increased. In this paper [19], planned to deal with the lifetime expansion problem, then improves a novel load balancing scheme by load balancing applying to the sub-network management in wireless sensor networks that balance the energy consumption of the sensor nodes and utmost network lifetime. In this study a scheme using analytical models and compare the results with the earlier researchers. This scheme takes into account the load balancing of individual nodes to maximize the system lifetime.
In this paper [20], authors proposed a clustering approach to providing the balanced cluster by considering thresholds for cluster formation and also address to reduce cluster unevenly and load unbalanced. It shows that it reduces the death rate of nodes when it compares with the other traditional approaches with a better lifetime of the network. It provides us an impartial cluster and better quality cluster. In this paper [21], a Hybrid Multihop Partition-Based Clustering routing protocol (HMPBC) is proposed . In this, the area of interest is divided into a number of zones, which a single-chain structure in the cluster is used to prolong the network lifetime and the region minimum spanning tree algorithm is adopted for communication among CHs. In order to reduce the number of forwarding in information interaction and lower energy consumption, we do not select CHs before transmission and we do select CHs in the

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transmission based on the comparison of the remaining energy; then, the nodes with much remaining energy become the CHs in the current round.

In this research paper, an investigation has been done on multi-hop routing protocols that was based on energy consumption of nodes and region density, cluster structure, network traffic etc. It has been found that the clustering can be used to expand the lifetime of a sensor network. Multi hop transmission with clustering can also increase network lifetime and scalability. However, it do not fit for real time application where large number of node deployed in the region. With respect to energy requirements, a real time energy efficient multi-hop cluster based routing protocol is needed for sensor networks

III. Proposed Mechanism: PMCC

A. Assumptions

In this section assumption about the network, model is described.

- Sensor nodes and base station are static.
- The base station does not limit by energy.
- Sensor nodes are aware of their location with respect to zone.
- The distributions of sensor nodes are random over the sensing area.
- The sensor nodes are densely deployed in the sensing area.
- Sensor nodes are homogeneous in energy level.
- Multi-hop communication is used for data transmission.
- Sensor nodes do not used any data aggregation technique.

B. Partition based Multi-Chain Clustering

The proposed PMCC protocol is designed to provide energy balance to uniformly and randomly deployed multi-hop WSNs with homogeneous nodes where the transmission range is γ. The PMCC protocol considers geographical routing in a stationary network. In the network, any node can be a source and can report events periodically or at the instant it occur.

Initial, sensor nodes determine their neighbor's positional information by exchanging a HELLO packet as soon as it observes an event. The Reply message contains the location coordinate of the node with its remaining energy. The energy cost of this process incurs a one packet transmission cost for each neighboring node and one overhearing cost.

The proposed approach consists two phases. First, cluster head selection and Second, chain formation. The problem of achieving a network wide energy balance is further broken down into the following two sub-problems: i) determine potential leader for data forwarding to cluster head and ii) determine a node for data forwarding.

C. Node Deployment

In this phase, deploy sensor nodes in sensing field. The node deployment is random; for that through sensor from outside of field or drop sensor from sky. After deployment, base station send a initialization packet. On hearing initialization packet each sensor become active for event monitoring. Each node continuously monitor the proximity of events. On occurrence of event near by nodes capture these events and process it.

D. Cluster head selection

In this phase, each node compute a priority value based on residual energy and distance to base station. The node with large value became a cluster head for the zone it belong to.

E. Chain formation

The cluster head node sends HELLO packet to all the nodes in the zone to get positional information of all the nodes. It determine the farthest nodes by comparing the distances of all the nodes. The cluster head node send a message to the farthest nodes to form chain. Therefore, farthest nodes considered as end node of chain. It finds nearest node and connect to it. For connection each node send a connection request to the nearest node. On reception of join request it connect to the request node as parent node if it is not the part of other chain. If it receive more than one join request at the same time then it will connect to the nearest node. Each node repeat these steps until all nodes are not joined to the one of the chain.

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TABLE I: Simulation Parameters

Parameters	Values
Area	$200 \times 200\ meter^2$
Base station position	$(100m, 100m)$
Total sensor nodes (n)	400
Initial energy (E_I)	0.5 J
Transmitter/Receiver electronics (E_{elec})	50 nj/bit
Reference distance (d_0)	87 meters
Transmit amplifier (ϵ_{fs})	10 pJ/bit/ m^2
Transmit amplifier (ϵ_{mp})	0.0013 pJ/bit/m^4

F. Determine leader of chain

In this phase, each chain chooses a leader that collect data of all the nodes of chain. It is selected on the basis of weight W. The weight W for each node i is calculated as

$$W_i = \frac{E_i}{Dist(CH, i)} \tag{1}$$

where E_i is the current energy level of node i and $Dist(CH, i)$ denotes distance between node i and its zone cluster head. The node with highest weight is considered as the primary leader of the chain and responsible for data forwarding to the cluster head node. With the leader node their are some other nodes work as pseudo leader. Each node i compare distances to cluster head $(Dist(i, CH))$ and parent $(Dist(i, P))$. If distance $(Dist(i, CH))$ is less than $(Dist(i, P))$, then the node i acts as a pseudo leader of the chain. It sends the collected data to the cluster head, instead of forwarding it to parent node.

G. Data collection

As soon as a node observed data from their sensor it forward to its parent node or to the cluster head node. After aggregating data received from chain members the leader nodes send it to cluster head. On reception of data from chains leader nodes, cluster head also perform data aggregation and forward it to the base station via multi-hop path formed using spanning tree method. Flow of proposed mechanism shown in Fig. 1.

IV. SIMULATION AND RESULTS

The performance of the proposed protocol, PMCC, was analyzed for network lifetime and energy consumption. Network lifetime is defined as the duration until all sensor nodes in the network becomes inoperative due to the depletion of energy. Energy consumption per round is defined as the average energy that is required to transmit all packet successfully in a round. The proposed routing protocol has been evaluated using MATLAB simulator. The simulation parameters are given in Table I.

The analysis of sensitivity in PMCC protocol has been done regarding length of network lifetime and energy consumption.

A. Initial energy of sensor node

To evaluate the effect of energy level on lifetime and energy consumption, number of simulation are performed. Four different level of energy are considered for each sensor node. The number of sensor node is taken as 400, deployed in $400 \times 400\ m^2$ area of sensing field with 40 meters communication range and base station placed at the middle of sensing field. Each node is equipped with 0.3 to 1 J of energy. It is assumed that in each zone only three chains are formed. The other parameters taken for simulation are shown in Table I.

Fig. 2a shows that the stability period of PMCC protocol is around 800 rounds when base station positioned at the middle of the sensing field. It has been observed from Fig. 2d that the stability period of PMCC protocol increases upto 2300 rounds. It has been observed from experiments that the stability period and network lifetime of PMCC protocol is increases with nodes initial energy. It has been observed that proposed protocol has very short unstable zone because protocol significantly balanced the network energy consumption for each node.

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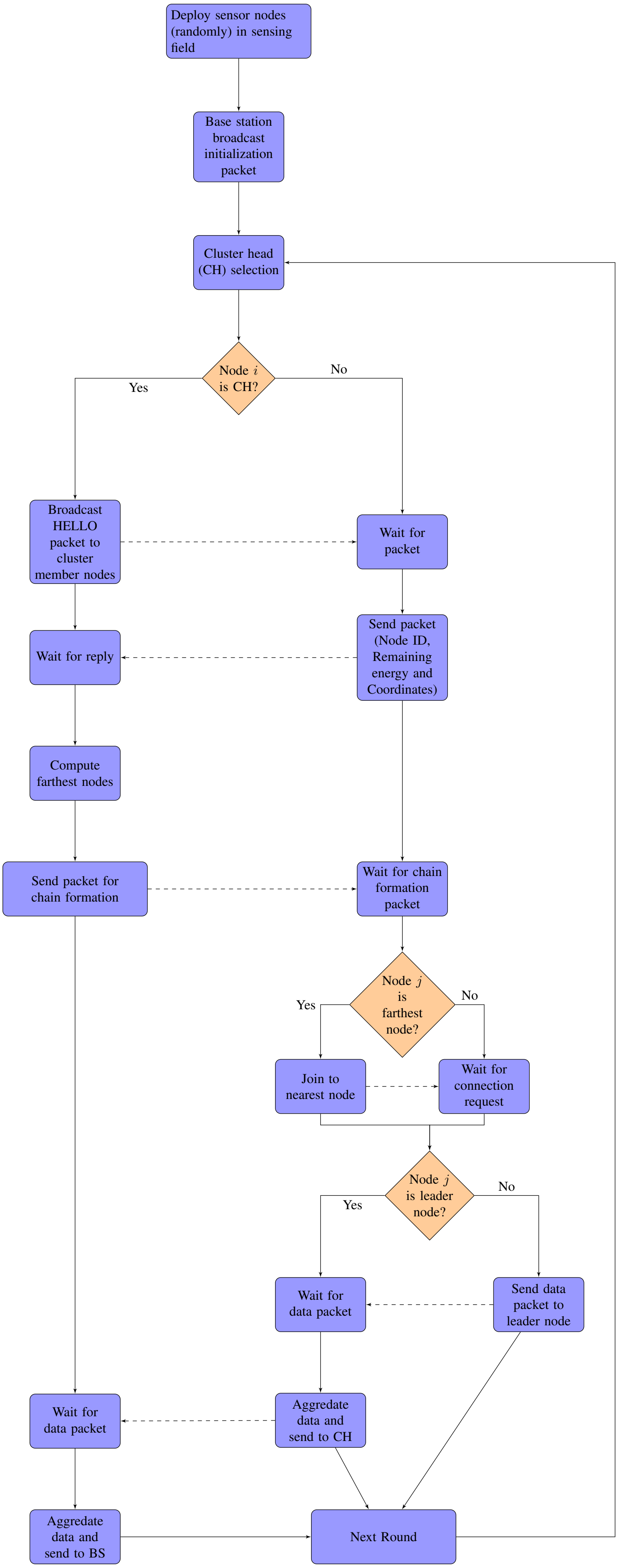

Fig. 1: Flowchart of Proposed Mechanism: PMCC

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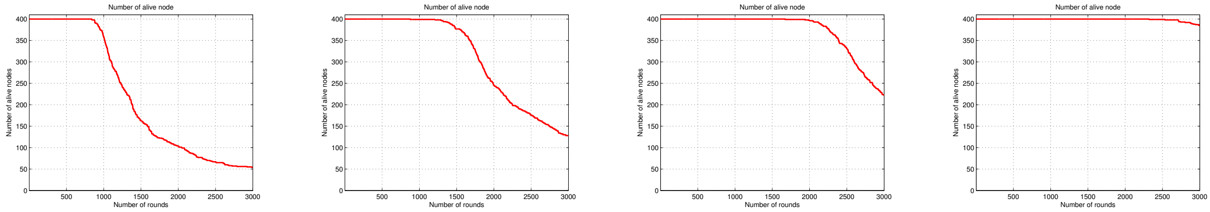
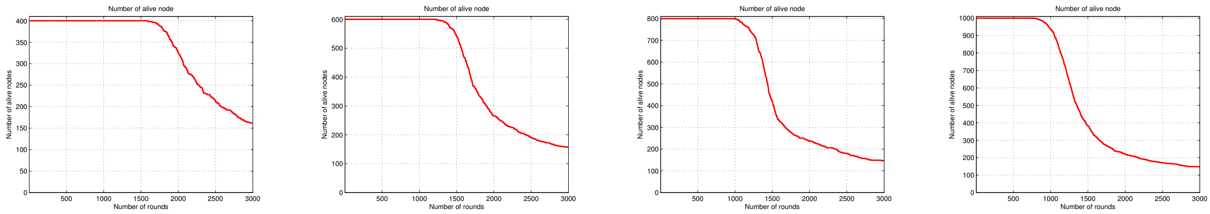


(a) Energy Level-0.3 (b) Energy Level-0.5 (c) Energy Level-0.7 (d) Energy Level-1.0

Fig. 2: Initial energy of sensor node with three chains.



(a) Sensor nodes-400 (b) Sensor nodes-600 (c) Sensor nodes-800 (d) Sensor nodes-1000

Fig. 3: 200×200 sensing field with three chains inside sink.

B. Number of Sensor Nodes

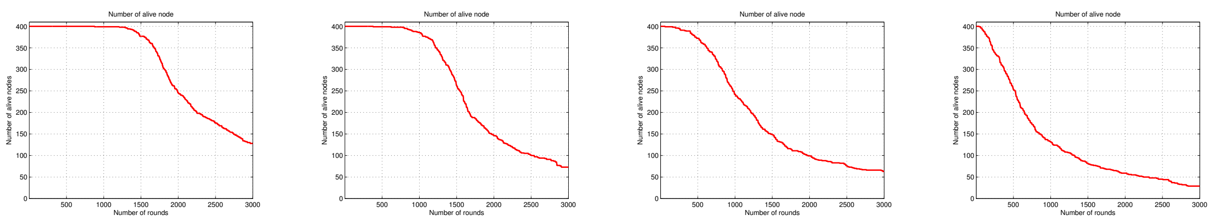
To analyse the effect of a number of sensor node (within the same field) on network lifetime and energy consumption four different values for number of sensor nodes has been considered in this simulation. This scenario simulated with 200×200 m^2 area where base station placed in the middle of sensing area. Each node is equipped with 0.5 J of energy. It is assumed that in each zone only three chains are formed.

Fig. 3 shows that the network lifetime of PMCC protocol is more than 3000 rounds for all value of sensor nodes. It also observed that network lifetime of this network is significantly large. Fig. 3a to 3d shows that increases in the number of nodes stability period of PMCC protocol is decreases because intermediate load increases on each node. It is found that the network lifetime of network is decreases with increase in sensor node but load balancing of network increases.

C. Sensing Field

To analyse the effect of sensing area on stability period and network lifetime, four different sized areas have been used. This scenario simulated with four hundred sensor nodes, are distributed in sensing field where base station placed in the middle of field. Each node is equipped with 0.5 J of energy.

Fig. 4a to 4d show that the stability period of PMCC protocol decreases with network area but data delivery remains constant. It has been observed that the increasing the sensing area decreases the stability period as well as a lifetime of the network, but data delivery is not much affected. Is is also observed that the load balancing in not affected by network size but load balancing increases maintain the network lifetime as huge increases in area but less change in lifetime.



(a) Sensing Field- 400×400 (b) Sensing Field- 600×600 (c) Sensing Field- 800×800 (d) Sensing Field- 1000×1000

Fig. 4: Four hundred sensor nodes with three chains inside sink.

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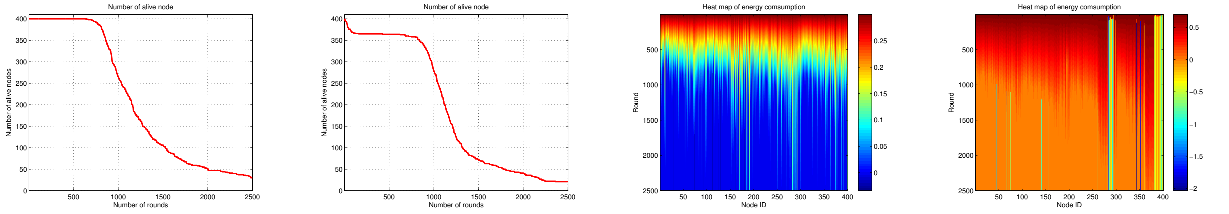
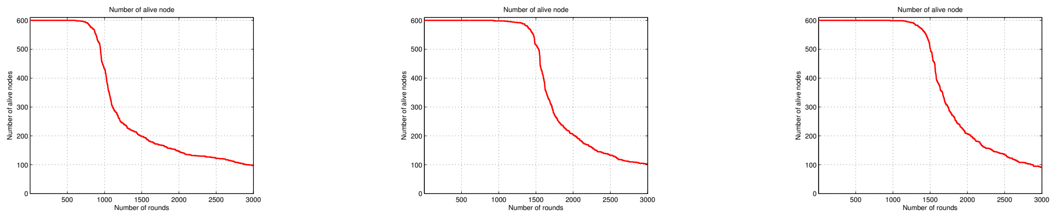


(a) Lifetime: Sink at corner (b) Lifetime: Sink at outside (c) Energy Heat-map: Sink at corner (d) Energy Heat-map: Sink at outside

Fig. 5: Sink position analysis.



(a) Number of Chains-2 (b) Number of Chains-3 (c) Number of Chains-4

Fig. 6: Six hundred sensor nodes are deployed in $400 \times 400\ m^2$ area.

D. Sink Position

In this, network lifetime and energy consumption is analysed for different position of sink/ base station. Two different position of sink has been considered in this simulation. Four hundred sensor nodes are distributed in $400 \times 400\ m^2$ area. Each node is equipped with 0.3/0.7 J of energy. It is assumed that in each zone only three chains are formed.

It has been observed for Fig.5a and 5b that the stability period of PMCC protocol is drastically changes. The sink position decide the energy consumption for inter cluster communication as shown in Fig. 5c and 5d. It is also observed that the farthest sink position, resultant more energy consumption which increases burden on sensor node. It has been observed that on increasing sink distance from network decreases the network lifetime.

E. Number of Chains

The effect of a different number of chains in the network on network lifetime, and energy consumption is analyzed. Simulation has been performed for three values of chains in the zone. In this simulation, six hundred sensor nodes are deployed in $400 \times 400\ m^2$ area where sink positioned at the middle of sensing field . Each node is equipped with 0.5 J of energy.

It has been observed for Fig.6a to 6c that the stability period of PMCC protocol is increases with increase in number of chains in each zone. It has been observed that on increasing number of chains, load of intermediate nodes decrease resultant the stability period and network lifetime increase significantly.

F. Performance Comparison

In this section the performance of EEHMCS [22], HMPBC [21] and PMCC are compared using the same network scenario. In this, nodes are randomly deployed in $200 \times 200\ m^2$ area. Each node installed with $0.5J$ energy and transmit data in 1000 byte sized packets.

Fig.7a illustrates the performance of EEHMCS, HMPBC and PMCC in a fixed network size. This figure shows that the PMCC protocol perform better than the other existing EEHMCS, HMPBC protocols. PMCC achieve better load balancing than the existing protocols. Along the 3000 rounds simulation of EEHMCS, HMPBC and PMCC, the termination rounds of the networks are 1461, 2041 and more than 3000 (lifetime-3542). The proposed protocol achieved 2 times and 1.7 times better lifetime than EEHMCS and HMPBC, respectively

The performance of protocols is also compared for energy consumption for fixed sensing field. It has been observed that the PMCC protocol has further stable average energy consumption and the preponderance in balancing network load. However, the PMCC significantly enhance network lifetime than EEHMCS, HMPBC as shown in Fig.7b.

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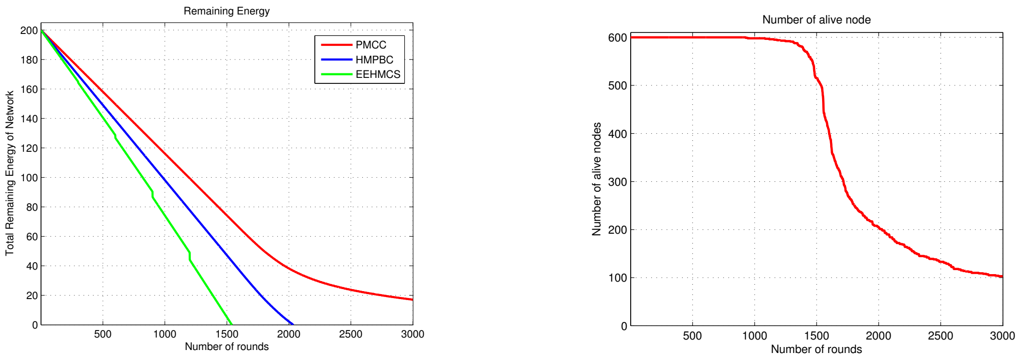

(a) Energy consumption (b) Average energy consumption of each node

Fig. 7: Performance comparison.

V. Conclusion

In this paper, a new protocol Partition based Multi-Chain Clustering (PMCC) is proposed to reduce energy consumption in routing process while managing load on sensor nodes for data transmission. The PMCC based on multi-hop routing in different region of the network, the routing process consist chain formation, selection of leader node, region/cluster head and data transmission. PMCC is very simple to implement in the short range sensor nodes. The sensor network lifetime is maintained and data has been successfully delivered in each round. Simulation results show that PMCC protocol has better load balancing as well as reliability than existing protocols.

References

[1] S. K. Gupta, N. Jain, and P. Sinha, "Node degree based clustering for wsn," *International Journal of Computer Applications*, vol. 40, no. 16, pp. 49–55, 2012.
[2] G. Gupta and M. Younis, "Load-balanced clustering of wireless sensor networks," in *Communications, 2003. ICC'03. IEEE International Conference on*, vol. 3, pp. 1848–1852, IEEE, 2003.
[3] K. Sun, P. Peng, P. Ning, and C. Wang, "Secure distributed cluster formation in wireless sensor networks.," in *ACSAC*, pp. 131–140, 2006.
[4] B. Nazir and H. Hasbullah, "Energy balanced clustering in wireless sensor network," in *2010 International Symposium on Information Technology*, vol. 2, pp. 569–574, IEEE, 2010.
[5] S. K. Gupta, N. Jain, and P. Sinha, "A density control energy balanced clustering technique for randomly deployed wireless sensor network," in *2012 Ninth International Conference on Wireless and Optical Communications Networks (WOCN)*, pp. 1–5, IEEE, 2012.
[6] S. K. Gupta, N. Jain, and P. Sinha, "Energy efficient clustering protocol for minimizing cluster size and inter cluster communication in heterogeneous wireless sensor network," *Energy*, vol. 2, no. 8, 2013.
[7] H. Zhang, L. Li, X.-f. Yan, and X. Li, "A load-balancing clustering algorithm of wsn for data gathering," in *Artificial Intelligence, Management Science and Electronic Commerce (AIMSEC), 2011 2nd International Conference on*, pp. 915–918, IEEE, 2011.
[8] N. Israr and I. Awan, "Multi-hop clustering algo. for load balancing in wsn," *International Journal of SIMULATION*, vol. 8, no. 1, 2006.
[9] N. Kim, J. Heo, H. S. Kim, and W. H. Kwon, "Reconfiguration of clusterheads for load balancing in wireless sensor networks," *Computer Communications*, vol. 31, no. 1, pp. 153–159, 2008.
[10] E. László, K. Tornai, G. Treplán, and J. Levendovszky, "Novel load balancing scheduling algorithms for wireless sensor networks," in *The Fourth Int. Conf. on Communication Theory, Reliability, and Quality of Service, Budapest*, pp. 54–49, 2011.
[11] S. Ozdemir, "Secure load balancing via hierarchical data aggregation in heterogeneous sensor networks.," *J. Inf. Sci. Eng.*, vol. 25, no. 6, pp. 1691–1705, 2009.
[12] Y. Zhang, Z. Zheng, Y. Jin, and X. Wang, "Load-balanced algorithm in wireless sensor networks based on pruning mechanism," in *Communication Software and Networks, 2009. ICCSN'09. International Conference on*, pp. 604–606, IEEE, 2009.
[13] M. Mahdavi, M. Ismail, and K. Jumari, "Load balancing in energy efficient connected coverage wireless sensor network," in *2009 International Conference on Electrical Engineering and Informatics*, vol. 2, pp. 448–452, IEEE, 2009.
[14] C. Canci, V. Trifa, and A. Martinoli, "Threshold based algo. for power aware load balancing in sensor networks," *IEEE Transaction, 0-7803-8916-6/05*, 2005.
[15] C. P. Low, C. Fang, J. M. Ng, and Y. H. Ang, "Load-balanced clustering algorithms for wireless sensor networks," in *2007 IEEE International Conference on Communications*, pp. 3485–3490, IEEE, 2007.
[16] Y. Deng and Y. Hu, "A load balance clustering algorithm for heterogeneous wireless sensor networks," in *E-Product E-Service and E-Entertainment (ICEEE), 2010 International Conference on*, pp. 1–4, IEEE, 2010.
[17] M. Zeynali, L. M. Khanli, and A. Mollanejad, "Fuzzy based approach for load balanced distributing database on sensor networks," *International Journal of Future Generation Communication & Networking*, vol. 3, no. 2, 2010.
[18] Y. Kavian *et al.*, "A load-balanced energy efficient clustering protocol for wireless sensor networks," *IET Wireless Sensor Systems*, 2016.
[19] H.-Y. Kim, "An energy-efficient load balancing scheme to extend lifetime in wireless sensor networks," *Cluster Computing*, vol. 19, no. 1, pp. 279–283, 2016.
[20] V. Pal, G. Singh, and R. Yadav, "Balanced cluster size solution to extend lifetime of wireless sensor networks," *IEEE Internet of Things Journal*, vol. 2, no. 5, pp. 399–401, 2015.
[21] C. Wang, Y. Zhang, X. Wang, and Z. Zhang, "Hybrid multihop partition-based clustering routing protocol for wsns," *IEEE Sensors Letters*, vol. 2, no. 1, pp. 1–4, 2018.
[22] A. Patra and S. Chouhan, "Energy efficient hybrid multihop clustering algorithm in wireless sensor networks," in *2013 IEEE International Conference on Communication, Networks and Satellite (COMNETSAT)*, pp. 59–63, IEEE, 2013.

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