Advanced ICH-LEACH protocol for Wireless Sensor Network using Optimization Approach

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Abstract: The deployment of Wireless Sensor Network (WSN) can be done in various kinds of applications such as military support applications, medical analysis, mechanical stress in bridges and buildings, and climate change observation, etc. For seamless performance of such tasks, more effective and energy efficient WSNs are needed. For the purpose of routing in WSN, various research and implementations have been conducted to design the energy-efficient protocols. LEACH protocol is considered as the one among the widely used energy-efficient protocols that involves some other changes into other protocols. For getting the accurate selection of CH, the performance of LEACH protocol is required to be enhanced comparatively based on the experimental investigation. For that, a new version of LEACH protocol known as ACO-ICH LEACH is proposed that includes amendments in the implementation that would have to provide the performance efficiently against the basic LEACH protocol. ACO (Ant Colony Optimization) is considered in this paper to choose the energy efficient route for transmission of information to the respective CH nodes for decreasing the usage of energy in inter-cluster and intra-cluster communication. The proposed protocol is improved the lifetime of a network with the reduction of consumption of energy which is proved by the simulation.

Keywords: Cluster head selection, ACO-ICH-LEACH, LEACH, Routing protocol, WSN, Energy efficiency, ICH-LEACH.

I. INTRODUCTION

The sensors are available in cheap costs and miniaturized size by developing the micro-electro mechanical system. Additionally, the main functions of sensors are included communicating wirelessly, sensing, and making computation. The architecture of sensors is involved three phases such as power source, data processors, and equipment's communication. The data related to the surrounding environment like vibration, temperature, etc. is measured by the sensors and they transform the information into electrical signals that can be used to perform the tasks by the processor unit [1]. The sensors either do store the information or send to the sensors once complete the collection of information. But, the limitation of sensors is included the resources in terms of communication, memory, processor's power, specifically the energy which plays a critical parameter for deciding the sensors' lifetime by considering a care for other elements [2].

A wide range of sensors are involved in the WSN generally that can be used for transmission of data and it will be collected to the particular node known as the base station. Different kinds of applications of WSN are related to the agriculture monitoring, traffic control, healthcare analysis, and industrial applications like control of machines and monitoring, and home automation. A lot of energy is consumed between nodes during the routing process that helps to demonstrate the lifetime of a network. The routing protocol of WSN has included two categories such as plane routing and level routing. Different types of protocols are included in the plane routing such as SAR [5], SPIN [4], and DD [3] etc. The other protocols like LEACH [7], TEEN [6], etc. are involved in the first category.

Based on scalar sensors, the interaction with the environment is included in the WSN. In various applications, the extracted information could be utilized such as computer vision, wireless communication, etc. Through the sink, the gathered information could be transmitted to different number of destinations. The specific characteristics involve in WSNs such as application-specification, resource constraints, and high bandwidth demand [2].

1.1 Routing Protocols

By using different routing techniques, the classification of routing protocols is made and is exploited in WSN [8]. Based on the operations of protocols, structures of a network, and routing processes that taken a decision regarding the routing algorithms for routing protocols, the routing techniques are implemented in WSNs.

1.2 Routing Models

The activities of transmission of sensed data are coordinated by a routing protocol in WSN according to the sensing nodes to the BS within the network. For routing protocols, three models have been divided in WSN [9] as follows:

1.3 One-hop model

As the transmission of information only occurred from all sensor nodes to BS in a network, a direct communication is represented by one-hop routing model [10] which is the popular model. The sensibility of direct communication may not be considered for the process of routing in WSN owing to the limited range of sensor nodes' transmission. That means, the practical applications can't be preferred to use this model.

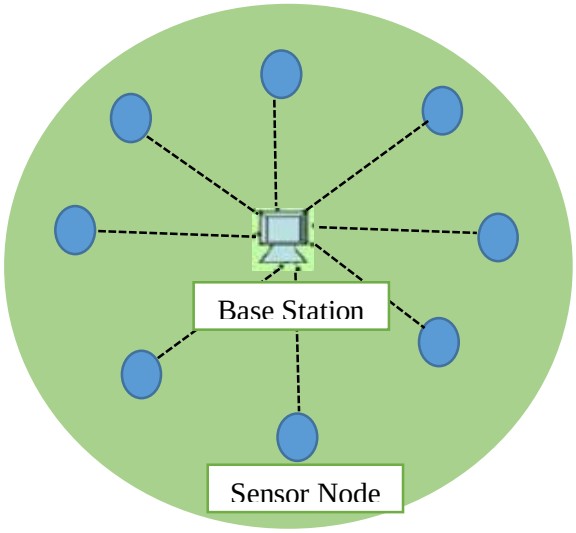

Figure 1: One-Hop Routing Model

1.4 Multi-hop Model

The data is sent by a sensor node to one of the neighbouring nodes that are nearer to the BS in the model of multi-hop routing [11]. From a specific source of sensor, the information is reached to the BS finally after multiple hoping the data.

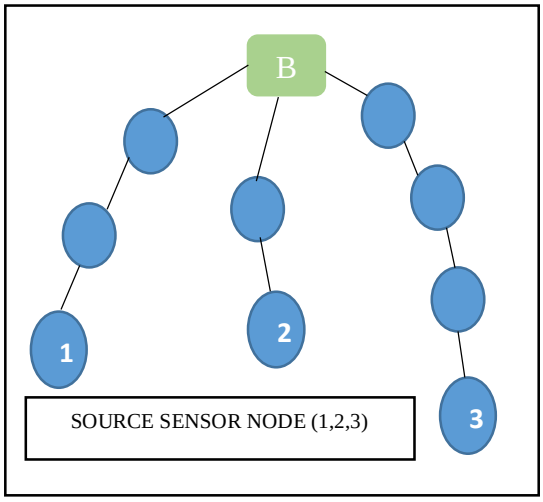

Figure 2: Multi-Hop Routing Model

1.5 Cluster-based hierarchical Model

The modelling of cluster-based hierarchical routing [12] is done for energy efficiency and the sensor nodes are formed into a cluster based on a single assigned CH for transmission of information towards BS. This model is useful for the hierarchical routings in WSN practically. For one cluster, a node could be a CH and a member for others also which is closer to the BS in this model.

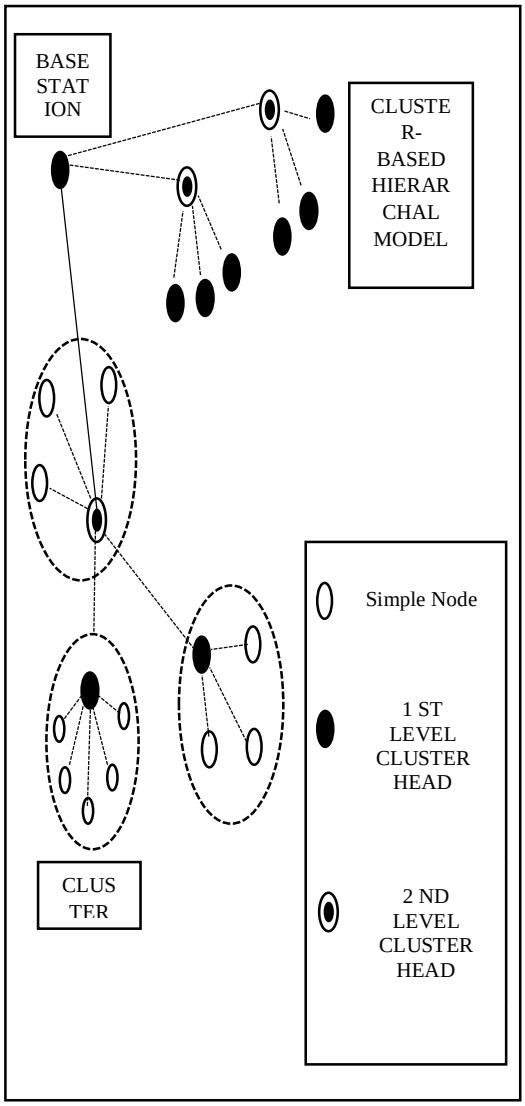

Figure 3: Cluster based Hierarchical Model

ICH-LEACH protocol is the energy-efficient hierarchical routing protocol. In addition to the basic LEACH, it's essential to understand the basic function and structure of hierarchical protocols. The research on ICH-LEACH with comparison has been evaluated comprehensively.

II. RELATED WORK

Wendi B. Heinzelman was proposed a LEACH protocol [7] which categorizes the simulation time into equal period of time known as round. Two phases are involved in a round such as steady phase and cluster setup phase. Each node has been chosen to be a cluster head or not for the current round in the initial phase. By utilizing a random number between 0 and 1, the selection of a cluster head is considered. The comparison of chosen number with the threshold T (n) is done.

In [13], the author has been focused on extension to LEACH protocol i.e. Modified LEACH protocol which is analyzed

critically and analytically. The lifespan of a WSN has impacted directly by the value of hard threshold in Modified LEACH protocol. Since the number of alive nodes will be more, the lifetime of a network will be increased with the more initial energy. The performance of Modified LEACH protocol is good when compared to the conventional LEACH protocol in every aspect which is revealed by the simulation and analytical results.

In [14], the author has been mentioned about the comparison of proposed protocol with the other descendants of LEACH protocol in transferring of images. Before sending of images to the network, the JPEG compression based on the images' frequency domain has been implemented with the help of application layer. The statistics related to the network's lifetime, consumption of energy, and statistics about received images will be determined by readers in this paper. For simulation of real constraints about transmission, Castalia framework is utilized. By improving the network's lifetime and transmission of more images with better quality, the simulation results are proved that the efficiency of the proposed protocol is achieved than other protocols.

A novel energy aware routing protocol is proposed by the author in [15] and it is termed as Energy Residue Aware (ERA) routing for improving the network's lifetime and balancing the consumption of energy in the network. To choose an efficient route from possible candidate return paths, each sensor is enabled by ERA. A path is chosen that could be with a maximum sum of energy residues rather than considering the selection of a path with minimum energy usage.

III. PROPOSED WORK

A LEACH protocol with an updated version will be proposed known as ACO-ICH LEACH by making amendments to the implementation. It would have to show better results than the basic protocol of LEACH. ACO (Ant Colony Optimization) is introduced to choose the route with energy efficiency for transmission of data to their respective CH nodes to enhance the consumption of energy in inter-cluster and intra-cluster communication. The searching for SINK node will be done by the CH nodes and the data is transmitted to the sink in an optimal path without compromising on energy efficiency. In this method, the placing of pheromone computing during return journey is not feasible for reflection of that path as the optimal in simulation period. The largest amount of pheromone and least amount of zero should have included in the strongest path and weakest path respectively. The changes in pheromone concentration should be selected the strongest path always amid of all competing stronger paths.

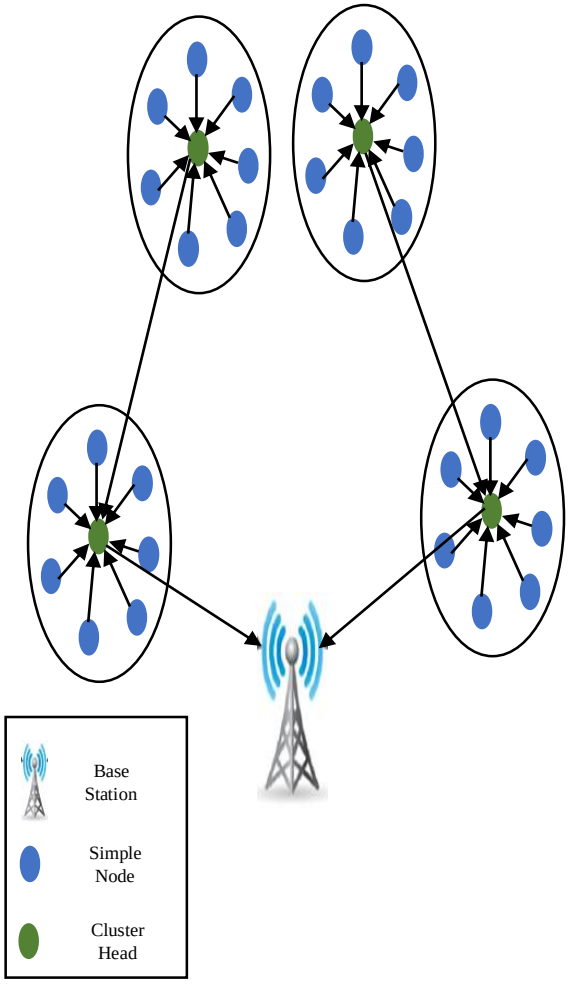

Figure 4: Structure of ICH-LEACH

The structure of ICH-LEACH is shown in the figure 2. Based on the parameters such as residual energy, distance and attenuation factor, the cluster head is chosen. According to the intermediate cluster heads, communications between sink and cluster head is involved in this protocol.

A. Initialization phase:

The coordinates are broadcasted by the sink to the network with all members based on a packet when the simulation is initiated. In addition to the signal strength of a packet, it stores the coordinates after a node is received the coordinates. For taking a decision regarding whether to transmit the data directly to the BS or note, the sink coordinates will be utilized by the chosen cluster-heads.

B. Cluster setup phase:

To get members, every cluster head in the network is promoted to other non-cluster heads itself in the phase of setup. The coordinates are sent by the cluster head and its distance from the sink to other cluster head. The data is stored with the information of a sink if the signal strength and the coordinates are sent to the cluster head. All cluster members

with a complete routing table has included in each cluster head. If a cluster head receives the information of a neighbour cluster members, this routing table is updated only and is created after completion of every round.

C. Steady phase:

The assigning of each cluster-head to its members is done in this phase and the collected data is sent by a frame window based on TDMA. The routing table is sorted and it has been collected after sending the information by the cluster-head. All cluster heads are chosen based on residual energy, distance, and attenuation factor. The information is sent to the SINK once completed the choosing of CH's in the network. Based on intermediate cluster heads, the SINK receives the data from some cluster heads.

ACO is implemented by considering below steps once the routing process of ICH-LEACH protocol has been completed.

1) The process of a network is started.
2) According to the selection procedure for hop nodes, the request of source node for destination is considered.
3) In a network, place the nodes randomly.
4) Destination location is to be established.
5) For sending the data, choose the routes for a path which is known before and ACO method is used.
6) To choose the efficient routing path, all neighbour nodes are verified.
7) Two working modes are included for the ants such as forward and backwards.
8) During search for the destination node, the memory of ant node is allowed them to retrace the path that it has followed.
9) From the memorized path, any routes are eliminated before moving backward on their memorized path. The pheromone is left by the ants on the arcs that they travelled during movement in backwards.
10) The data is transmitted from source to destination after completion of choosing the routing path.

IV. RESULTS AND DISCUSSION

Based on network simulator NS-2, the proposed scheme ACO-ICH-LEACH performance is assessed and compared with the original LEACH and ICH-LEACH protocols. By using metrics like Average End to End Delay (E-to-E Delay), Energy Consumption (EC), and Throughput, the proposed protocol outcome is computed and compared. In table 1, the parameters of simulation are demonstrated.

PARAMETER	VALUE
Application traffic	CBR
Transmission rate	512 bytes/ 0.5ms
Radio range	250m
Packet size	512 bytes
Clusters	8
Routing Protocol	AODV
Simulation time	10s
Number of nodes	21
Area	1000 x1000
Malicious nodes	ACO-ICH-LEACH, ICH-LEACH, LEACH
Transmission Protocol	UDP

Table1: Simulation parameters

To study and assess the proposed protocol, the version of Network Simulator (NS2) 2.35 is utilized. In a region of 1000 x 1000 m^2, 21 nodes are contained according to the simulation context. For ideal unstructured, the mobility of Random Way Point (RWP) is utilized and the transmission range is set to 250m. Two types of scripts are exploited such as the first one (code.tcl) for generation of random traffic for constant bit rate (CBT) of 521 bytes based on the UDP protocol. For all tests, 10s of simulation time has been set. The routing information is supported in the simulation and can be shared with all nodes while simulating the network.

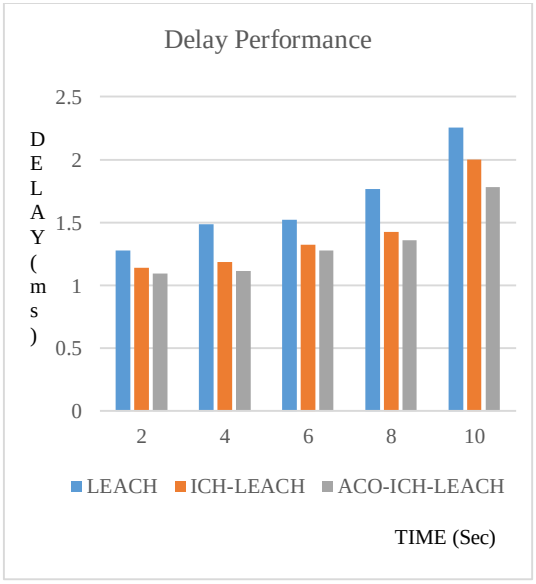

Figure 5: End-to-End Delay

End to end delay in regard to the simulation time is represented in figure 5. Based on the showed results, a lower E2E delay has included in the ACO-ICH-LEACH when compared to one of the ICH-LEACH and LEACH protocols. The optimum routing process and reducing the transmission time between nodes in ACO based ICH-LEACH is lead to the minimization of E2E delay.

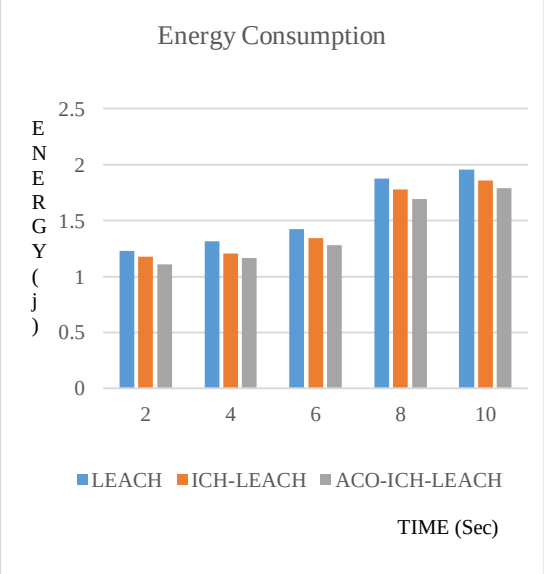

Figure 6: Energy Consumption

Figure 6 is presenting the energy vs. simulation time results for LEACH, ACO-ICH-LEACH and ICH-LEACH. Lower amount of energy has been consumed in ACO-ICH-LEACH than the LEACH and ICH-LEACH. According to the parameters and the proposed method is predicted the failure of a link in prior to the loss of energy for all individual nodes, the best route is selected for ACO-ICH-LEACH. This will be resulted in the lower conservation of energy in the proposed protocol.

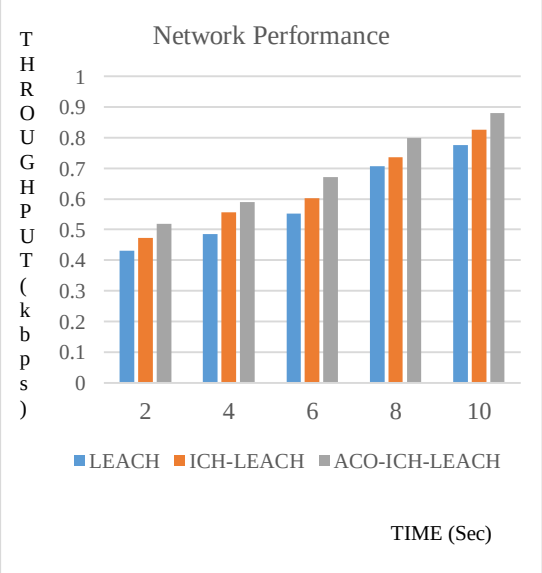

Figure 7: Throughput

The throughput vs. simulation time of ACO-ICH-LEACH, ICH-LEACH, and LEACH are illustrated in figure 7. The higher throughput is shown in the proposed protocol when compared to the ICH-LEACH and LEACH. With the optimal route selection, the efficient route is chosen for ACO-ICH-LEACH that results in increasing the lifetime. Before dropping of data packets, the link failure is detected by the proposed ACO-ICH-LEACH. All of these will help to achieve the higher throughput for the proposed protocol.

V. CONCLUSION

In this paper, a new framework named as ACO based ICH-LEACH protocol is designed by considered the security as a major concern in wireless sensor networks. The modified algorithmic rule for ACO-ICH-LEACH protocol is provided best performance based on the analyzation of results. The comparison of proposed protocol of ACO-ICH-LEACH with the other protocols such as LEACH, and ICH-LEACH is done based on different parameters such as detection time and consumption of energy. The greater results are performed by the ACO-ICH-LEACH in throughput, conservation of energy, and end to end delay with the simulation results using NS-2 simulator. However, the ACO was implemented for WSN to select the optimal route for intra cluster and inter cluster communication. The network's lifetime and routing performance are enhanced as a result.

VI. REFERENCES

[1] D. Estrin, D. Culler, K. Pister, and G. Sukhatme, "Connectingthe physical world with pervasive networks," *IEEE PervasiveComput.*, vol. 1, no. 1, pp. 59–69, Jan. 2002.

[2] I. F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci,"A survey on sensor networks," *IEEE Commun. Mag.*, vol. 40,no. 8, pp. 102–114, Aug. 2002.

[3] C. Intanagonwiwat, R. Govindan, D. Estrin, J. Heidemann, andF. Silva, "Directed Diffusion for Wireless Sensor Networking,"*IEEEACM Trans Netw*, vol. 11, no. 1, pp. 2–16, Feb. 2003.

[4] W. R. Heinzelman, J. Kulik, and H. Balakrishnan, "AdaptiveProtocols for Information Dissemination in Wireless SensorNetworks," in *Proceedings of the 5th Annual ACM/IEEEInternational Conference on Mobile Computing andNetworking*, New York, NY, USA, 1999, pp. 174–185.

[5] K. Sohrabi, J. Gao, V. Ailawadhi, and G. J. Pottie, "Protocolsfor self-organization of a wireless sensor network," *IEEE Pers.Commun.*, vol. 7, no. 5, pp. 16–27, Oct. 2000.

[6] A. Manjeshwar and D. P. Agrawal, "TEEN: a routing protocolfor enhanced efficiency in wireless sensor networks," in *Paralleland Distributed Processing Symposium., Proceedings 15th International*, 2001, pp. 2009–2015.

[7] W. R. Heinzelman, A. Chandrakasan, and H. Balakrishnan,"Energy-efficient communication protocol for wirelessmicrosensor networks," in *Proceedings of the 33rd AnnualHawaii International Conference on System Sciences, 2000,*2000, p. 10 pp. vol.2–.

[8] Al-Karaki, Jamal N., and Ahmed E. Kamal. "Routing techniques in wireless sensor networks: a survey." *IEEE wireless communications* 11, no. 6 (2004): 6-28.

[9] Baghyalakshmi, D., Jemimah Ebenezer, and S. A. V. Satyamurty. "Low latency and energy efficient routing protocols for wireless sensor networks." In *2010 International Conference on Wireless Communication and Sensor Computing (ICWCSC)*, pp. 1-6. IEEE, 2010.

[10] Fedor, Szymon, and Martin Collier. "On the problem of energy efficiency of multi-hop vs one-hop routing in wireless sensor networks." In *21st International Conference on Advanced Information Networking and Applications Workshops (AINAW'07)*, vol. 2, pp. 380-385. IEEE, 2007.

[11] Abdulla, Ahmed EAA, Hiroki Nishiyama, Jie Yang, Nirwan Ansari, and Nei Kato. "HYMN: A novel hybrid multi-hop routing algorithm to improve the longevity of WSNs." *IEEE Transactions on Wireless Communications* 11, no. 7 (2012): 2531-2541.

[12] Jan, Mian Ahmad, Priyadarsi Nanda, Xiangjian He, and Ren Ping Liu. "Enhancing lifetime and quality of data in cluster-based hierarchical routing protocol for wireless sensor network." In *2013 IEEE 10th International Conference on High Performance Computing and Communications & 2013 IEEE International Conference on Embedded and Ubiquitous Computing*, pp. 1400-1407. IEEE, 2013.

[13] S. H. Gupta, R. K. Singh, J. Bodi and D. Chandhok, "Evaluation & analysis of energy efficient extension to LEACH protocol for WSN," *2015 IEEE Power, Communication and Information Technology Conference (PCITC)*, Bhubaneswar, 2015, pp. 686-690.

[14] Taj, Bennani, and Mhamed Ait Kbir. "Comparing ICH-leach and Leach Descendents on Image Transfer using DCT." *International Journal of Electrical & Computer Engineering (2088-8708)* 8, no. 4 (2018).

[15] Chen, Huan, Cheng-Shong Wu, Yuan-Sun Chu, Chih-Chuan Cheng, and Li-Kuang Tsai. "Energy residue aware (ERA) clustering algorithm for leach-based wireless sensor networks." In *2007 Second International Conference on Systems and Networks Communications (ICSNC 2007)*, pp. 40-40. IEEE, 2007.