Real Time Meteorological Solar Data Based Modified Solar Aware LEACH

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Abstract: In hostile and non-accessible remote area, energy conservation plays vital role in the performance of Wireless Sensor Network (WSN). Shorter life of battery operated sensors tends to lower lifespan of the WSN which further degrades the dense network performance. In this paper, we propose the modified solar aware LEACH for efficient routing in WSN to maximize the network lifespan. This proposed scheme uses real time solar meteorological data for the implementation of solar aware LEACH (sLEACH), advance solar aware LEACH (A-sLEACH), improved solar aware LEACH (IS-LEACH).The proposed algorithm is simulated using MATLAB and performance is evaluated on the basis of data throughput, energy consumption and network lifetime which show improved performance than existing techniques.

Keywords : Wireless Sensor Network, LEACH, solar energy

I. INTRODUCTION

Wireless Sensor Network (WSN) is the group of interconnected sensor nodes distributed over the plane. WSN plays vital and sensitive role in disaster management, habitat monitoring, military applications, healthcare applications, home automation, industrial automation, environmental monitoring, transport and logistics management etc. On the basis of deployment of the sensor nodes, WSNs are categorized as terrestrial WSN, under Terrestrial WSNs, Underground WSNs, Underwater WSNs, Multimedia WSNs and Mobile WSNs.

Sensor node from the WSN has the ability of data collection, processing, synchronization, storage and communication model. Generally, sensor nodes are operated with the tiny non-replaceable and non-rechargeable battery which has very shorter life. Sensor nodes lifespan depends upon battery life, and lower battery life degrades the data aggregation and data throughput of the network. There are many conventional energy resources are available in the environment but solar energy is most accessible, available and harvestable resource. Therefore, it is attractive to use the battery operated on renewable energy sources such as solar energy and wind energy in the extreme remote or battlefield area.

In this paper, we have employed the real time meteorological data for the selection of efficient cluster heads (CHs) in sLEACH, A-sLEACH and IS-LEACH for efficient routing in WSN.

In this, only solar operated nodes are elected as CH. Solar battery operated sensor nodes increases the lifespan of the sensor nodes which further increases the probability of selection of solar operated nodes as the CHs.

The paper is organized as follow: Section II describes the previous work on the hierarchical based routing algorithms in WSN. Further, section III gives the information about proposed modified sLEACH algorithm for real time metrological data. In section IV, modified A-sLEACH is described for the real time solar data. Subsequently, details about modified IS-LEACH for the real time meteorological data are given in section V. Section VI gives the discussion on the experimental results and performance of the network under various scenarios. Last section concludes the proposed work and explains the open background for further improvement.

II. RELATED WORK

In hierarchical routing algorithms, central controller takes the routing decision to achieve the lower delay and higher energy efficiency. In this, data is propagated from the cluster head (CH) to base station (BS).

Wendi B. Heinzelman [8] has presented Low Energy Adaptive Clustering Hierarchy (LEACH) as the first energy efficient hierarchical routing Algorithm on the basis of re-clustering and self organization of each sensor node for every round. In this because of added overheads on the CHs, more energy consumption takes place. LEACH fails to give accurate information about position and number of CHs in each round. CHs places at longer distance from BS causes uneven energy dissipation, thus reduces the network lifetime. Centralized LEACH (LEACH-C) [9] uses BS for the decision of CHs on the basis of average energy of all the nodes which is energy efficient than LEACH but has less scalability. Further, Thiemo Voigt [10] have presented solar aware LEACH (sLEACH) in which the centralized controller selects solar energy operated nodes as the CH to maximize the to maximize the network lifetime. In sLEACH, for the smaller sun duration, CHs handover takes place. Multi-hop LEACH [11] is an extension of LEACH which is used to tackle the problem of higher energy dissipation in the large WSN when the CHs are located at longer distance from BS. In multi-hop LEACH, data is routed form to the BS via intermediate CHs having minimum number of hops. Further, mobile LEACH (mLEACH)[12] which is used in heterogeneous WSN which considers the mobility and power attenuation of sensor nodes for the selection of CHs .Advancement in LEACH has been proposed in Power-Efficient Gathering in Sensor Information Systems (PEGASIS) [13] which is an optimal chain based protocol.

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PEGASIS uses chain of sensor nodes to transmit the information to BS rather than forming the clusters. LEACH-Fixed (LEACH-F) [14] has fixed number of clusters in which any node can be elected as CH in its cluster.

It has poor performance in dynamic network and node addition and deletion is not possible as all nodes must be immobile. LEACH-Balanced (LEACH-B) [15] used the decentralized method which enhances the network lifespan by considering the position of the node and receiver node position using GPS which is not practicable in WSNs. In LEACH-ET [16] an energy threshold (ET) value is employed to estimate the CHs. If any CH reaches to the threshold value it is changed from the CH position and if any normal node reaches to threshold value it is eliminated from the race of being CHs. In Tow Level-LEACH (TL-LEACH) [17] CHs were divided in primary and secondary CHs. Secondary CHs aggregates data from the sensor nodes and transmits it to primary CHs. It resulted in energy balanced, scalable and robust for dense network. Advanced solar aware LEACH (As-LEACH) [18] was proposed to minimize the waiting time solar LEACH. In Time Based-LEACH (TB-LEACH) [19], CHs selection and formation dependent on the random timer for the cluster selection. Mobile Agent based-LEACH (MAT-LEACH) [20] was a mobile agent nodes are selected as the CHs to avoid more energy consumption at the CHs.

Many LEACH versions have been presented in the past but still it faces challenges of lower lifetime, lower packet ratio, higher battery usage, scalability, localization etc.

III. PROPOSED METHODOLOGY

Solar energy has very less maintenance, long term application and increases the autonomy of the sensor node. Solar energy is most reliable resource of energy which is daily predictable. In solar energy operated WSN, the sensor node propagates the data without consuming the battery energy. The solar batteries have recharging capability if it gets discharged during absence of sunlight. Again the batteries can be used as backup when the node failure takes place. According to meteorological data the discrepancy of sun intensity in a day is well estimated by a Gaussian function [22]. The charged voltage level of solar panel having dimensions 356mm, 352mm, 28mmwith an open circuit voltage of 5.94V and short circuit current of 109.4mA recorded every hour on 20 January, 2019 in a full day as shown in figure 1. It is found that the battery is recharged to maximum energy during the afternoon hours between 11.00 am to 4 pm.
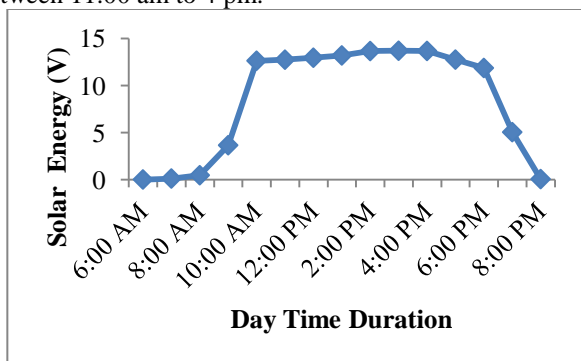

Figure 1 Solar power vs time plot

A) Modified sLEACH

In solar aware LEACH [10], the authors have implemented the system on OMNET++ and not considered the detailed information of solar model used. However, he also stated in the future scope that his solar model can be improved by either by using data available from meteorology or biology. In our approach real time meteorological solar data is used and simulation is done in MATLAB for the distributed solar aware LEACH. All the simulation parameter and CH selection process remains same as original work for comparison purpose. However, in distributed sLEACH, only solar powered nodes are selected as the CHs with higher probability. In this the node is selected as the CH only if it is less than the threshold value T_n as shown in equation 1. The threshold value is dependent on the scaling factor Ks. Scaling factor is >1 for the solar operated nodes and reciprocal to the normal sensor nodes which increases the selection probability of the solar operated nodes. This parameter is chosen as 4 for solar powered nodes and 0.25 for normal nodes which is same as in original work [10]. P is the prior determined value which estimates the average number of cluster heads during one round. In generalized LEACH every node becomes CH exactly once in 1/P round whereas in sLEACH solar aware nodes can be re given chance of reselection of CH and the same policy used in modified distributed sLEACH. CHN is number of cluster heads selected till last round and numNodes is total number of nodes in the network. When CHN reaches to the numNodes, CHN is reset to 0 for next round.

$$T_n = K_s * \frac{P}{1 - \left(\frac{CHN}{numNodes}\right)}. \qquad (1)$$

B) Modified A-sLEACH

An advance solar aware LEACH [18] is successor of the LEACH algorithm which uses cluster heads are selected from the solar nodes from the convex hull region. In this paper, author has proposed many new approaches for the improvement in lifetime but in modified distributed A-sLEACH, only selection process of CH is same as original A-sLEACH with real time solar data and radio model kept same for all proposed modified variants of LEACH. BS station advertize the broadcast message to the every node which consists of the CH ID. In our approach, for the dense network, the vertices of convex hull plot is used for the CH selection and only solar powered nodes are selected as CHs and every time only polar powered nodes are given chance to become CH. In this, solar power nodes are manually deployed for better coverage of the network and rests of the nodes are randomly deployed. Then each sensor node propagates the message to the BS by using non-persistent CSMA protocol for minimization of waiting state and collision avoidance. For scheduling TDMA is used and for data aggregation First In First out (FIFO) scheme is employed.

C) Modified IS-LEACH

Improved LEACH [21] allows only solar power nodes for the cluster head selection. The network is randomly deployed and the selection of the solar powered nodes as cluster head are done randomly in modified distributed IS-LEACH in which the solar power is given to any 5, 10, etc random nodes. In our approach also only solar powered nodes become cluster head all the time. The selection of same CH in each round has many advantages like the stability of the network is maintained and also no need of additional control messages which really helps in improving the network lifetime.

It uses Time Division Multiple Access (TDMA) as medium access control (MAC) protocol which brings the node in sleeping mode when it is in idle mode to save the energy. To improve the performance of the IS-LEACH, we have used real time meteorological solar data.

D) Energy Radio model

In all above modified variants of distributed LEACH uses same radio model for transmission of data from normal nodes to CH and from CH to BS. While transmitting the data towards the BS the energy consumption depends upon the distance of BS from the CH. The total energy consumption for consumption of 1 bit data is given in equation 2.

$$E_{Tx} = \begin{cases} L * E_{elec} + L * E_{fs} * d^2, & \text{if } d < d_o \\ L * E_{elec} + L * E_{mp} * d^4, & \text{if } d \geq d_o \end{cases} \quad (2)$$

Where, L is the number of bits, ETx is energy consumed for transmission of L bits, Efs is the amplification factor for free space, Emp is the amplification factor for multipath channel, do is threshold distance, and Eelec is energy dissipated per bit. If the distance of neighboring node is less than the

range of nodes, then less energy will be consumed than the distance which is greater than the range of the node. The total energy consumed for receiving L bits is given by equation 3.

$$E_{Rx} = L * E_{elec} \quad (3)$$

IV. RESULTS & DISCUSSIONS

The proposed algorithm is simulated using MATLAB on the system having specification such as intel(R) core(TM) i3-3110 processor CPU @2.64 GHz, 4 GB RAM and 64 bit windows operating system. The performance of the proposed algorithm is evaluated on the basis of network lifetime, energy consumption and packet throughput. The network scenario parameters used for the implementation of system are given in Table 1.

Table 1. Network scenario simulation parameters

Parameter	Specification
Network Area	100 m X 100 m
Number of Sensor Nodes (n)	100
Number of Solar Nodes (n)	5,10,15,20, 25etc
Initial Energy of each Node	0.5J
Simulation Time	30 sec
Traffic Patterns	CBR (Constant Bit Rate)
MAC Protocol	802.11
Threshold Distance(do)	$\sqrt{E_{fs}/E_{mps}}$
Energy Dissipated per bit (E$_{elec}$)	50 nJ /bit
Transmission Power Dissipation (E$_{TX}$)	50 nJ /bit
Receiver Power Dissipation (E$_{RX}$)	50 nJ/bit
Amplification Factor for Free Space(Efs)	10pJ/bit/m2
Amplification Factor for Multi Path (Emp)	0.0013pJ/bit/m4
Message bits (K)	2000 bits
Percentage of nodes that becomes cluster head (P)	0.05

Performance evaluation results for modified sLEACH, A-sLEACH, and IS-LEACH are shown in figure 2, 3 and 4 respectively. For the performance evaluation the solar powered nodes are varied from 5, 10, 15, 20 and 25 etc which surely increases the network life time and reduces the

battery utilization. The proposed method improves the probability of solar nodes selection as a CH, thus as we increase the number of solar powered nodes increases the lifetime of the network which delays the early death of nodes, large number of operational sensor nodes per round, larger energy consumption per round and higher data transmission to the CH and BS.
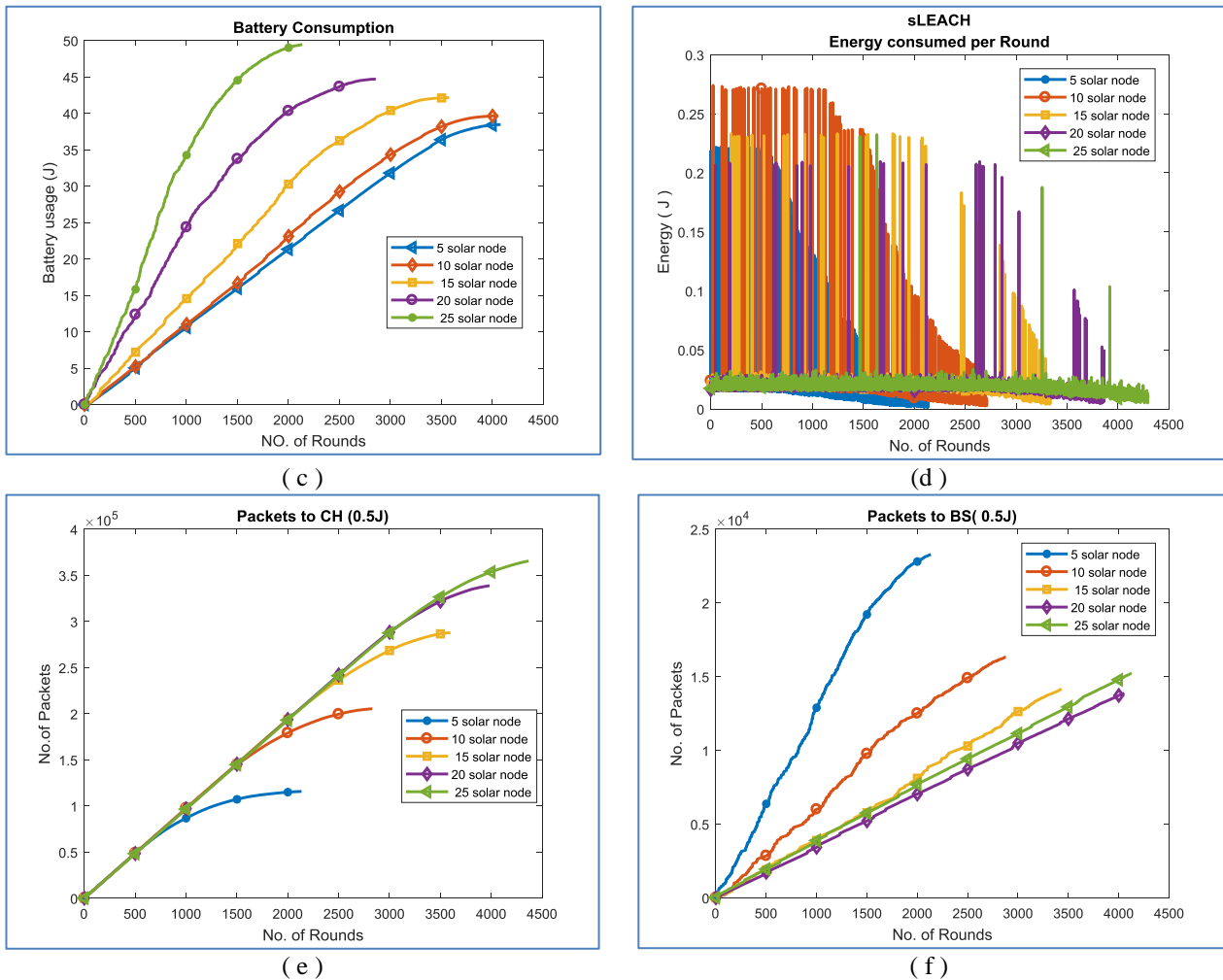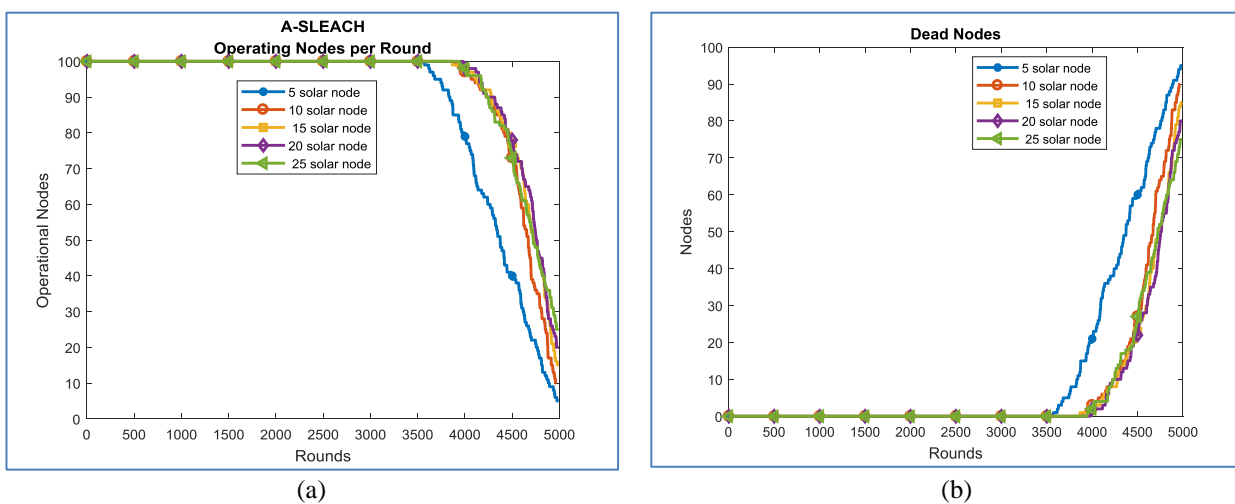
(a)

(b)

(c)

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(e)

(f)
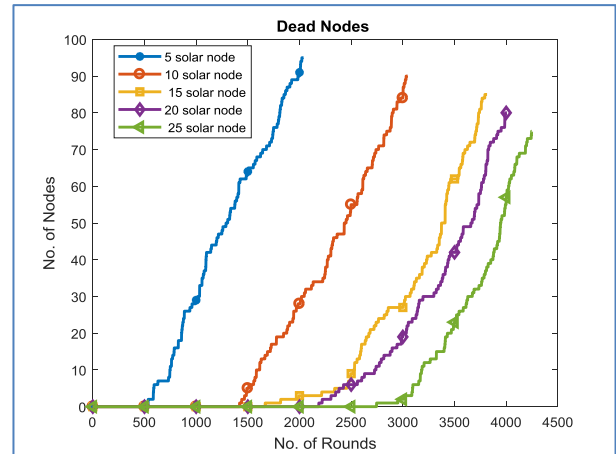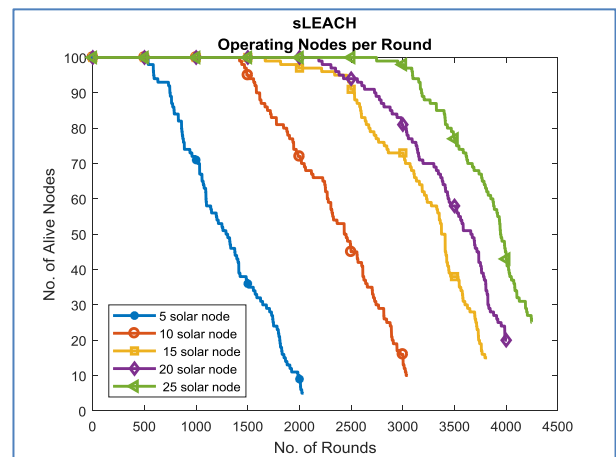
Figure 2: Experimental results of modified distributed sLEACH for real time solar data) Dead nodes per round for various number of solar nodes b) Live nodes per round for various number of solar nodes c) Battery consumption per round for various number of solar nodes d) Energy consumption per round for various number of solar nodes e) Packets to CH per round for various number of solar nodes f) Packets to BS per round for various number of solar nodes

(a)

(b)

(c)

(d)

(e)

(f)

Figure 3: Experimental results of modified distributed A-sLEACH for real time solar data a) Dead nodes per round for various number of solar nodes b) Live nodes per round for various number of solar nodes c) Battery consumption per round for various number of solar nodes d) Energy consumption per round for various number of solar nodes e) Packets to CH per round for various number of solar nodes f) Packets to BS per round for various number of solar nodes
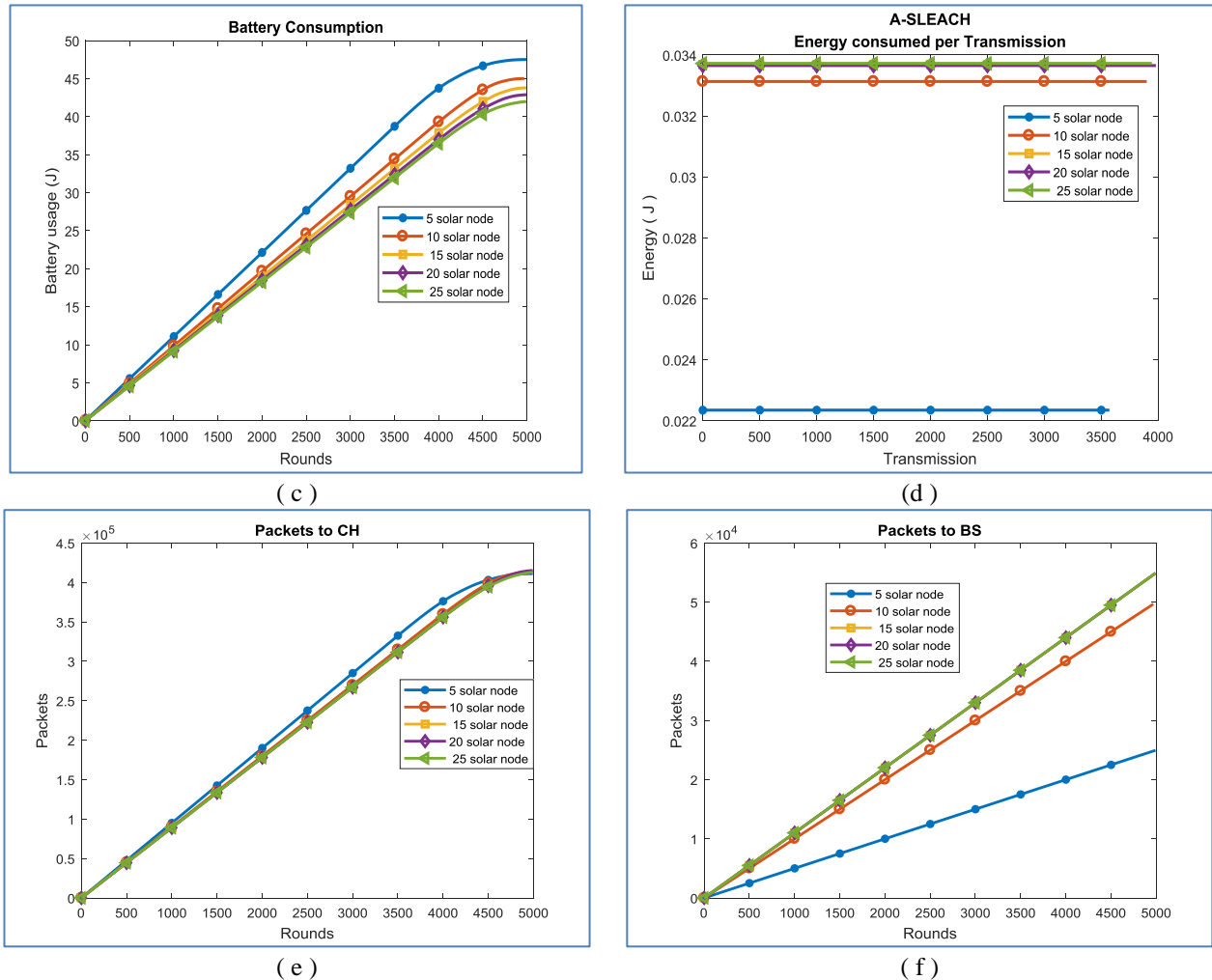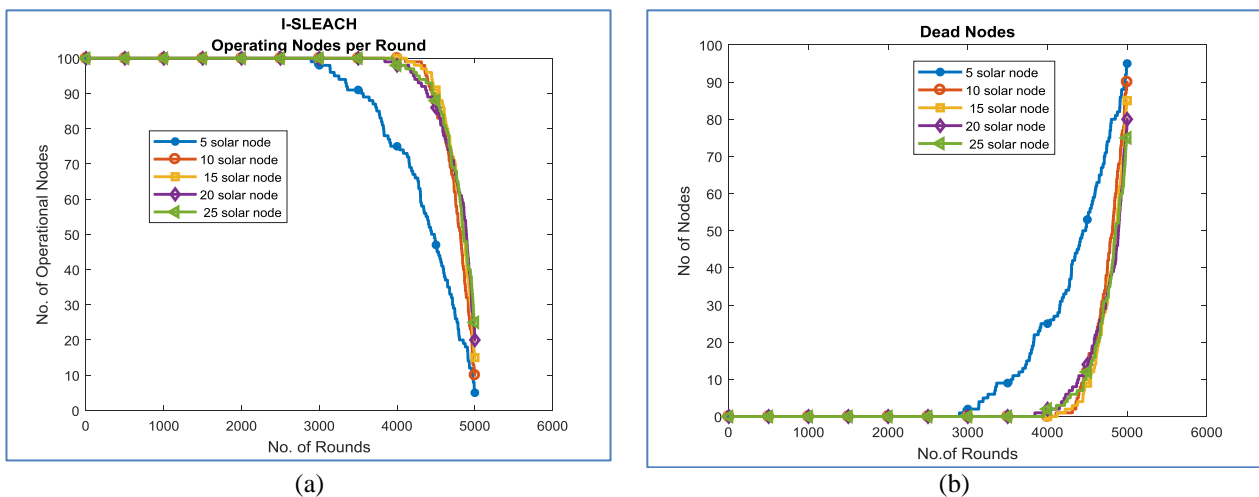

(a)

(b)

Figure 4: Experimental results of modified distributed IS-LEACH for real time solar data a) Dead nodes per round for various number of solar nodes b) Live nodes per round for various number of solar nodes c) Battery consumption per round for various number of solar nodes d) Energy consumption per round for various number of solar nodes e) Packets to CH per round for various number of solar nodes f) Packets to BS per round for various number of solar nodes
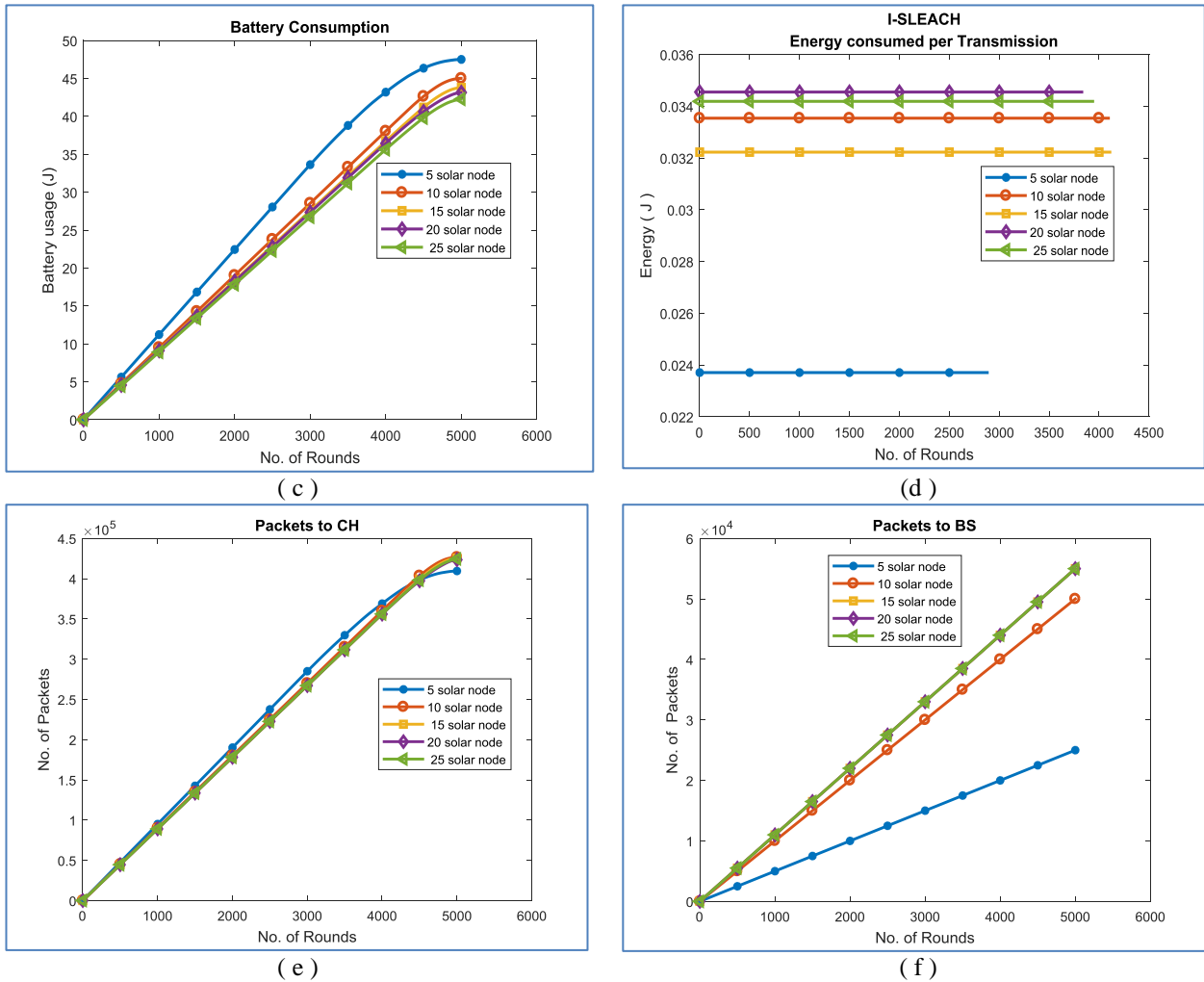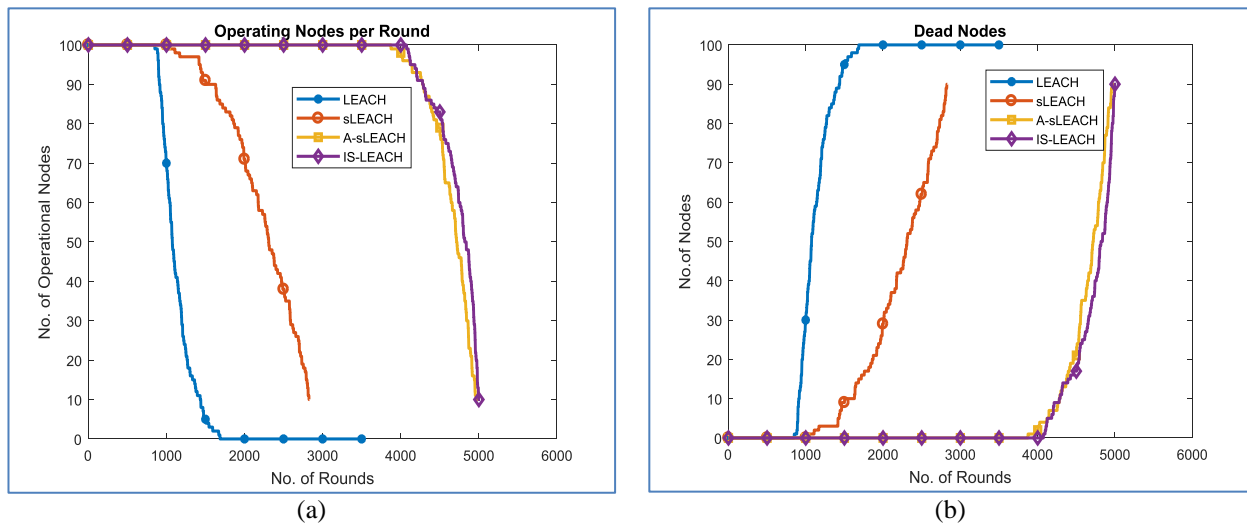
Figure 5: Overall comparative results of modified, distributed sLEACH, A-sLEACH and IS-LEACH for real time solar data a) Dead nodes per round for various number of solar nodes b) Live nodes per round for various number of solar nodes c) Battery consumption per round for various number of solar nodes d) Energy consumption per round for various number of solar nodes e) Packets to CH per round for various number of solar nodes f) Packets to BS per round for various number of solar nodes.
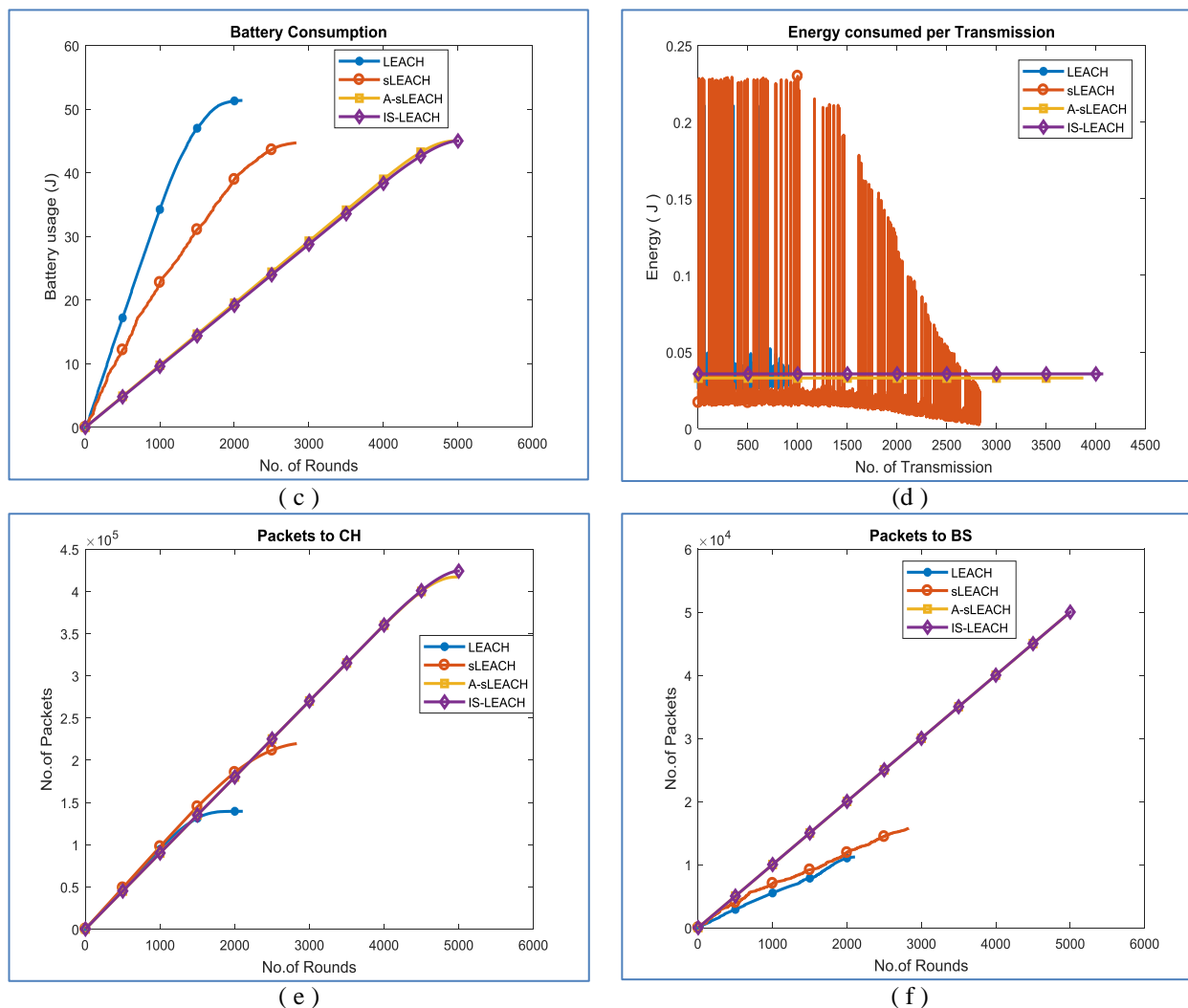
Figure 2(a) and 2(b) shows the network life time improvement as the number of solar powered nodes are increased in the network and these solar powered nodes remains alive in the network. Figure 2 (c) shows battery consumptions which clearly indicate that as the number of solar powered nodes increased in the network the battery consumption is reduced. Figure 2 (d) shows energy consumption per round which is also decreased with the increasing no. of nodes and shows lot of variation in energy consumption due to CH selection process. Figure 2 (e) and figure 2(f) shows the no. of packets transmitted to the CH and BS respectively. Due to data aggregation at CH the no. of packets transmitted to BS are less as compared to CH and also increasing the number of solar powered nodes increases the data redundancy. Figure 3a) and figure 3b) shows the increase in network lifetime up to 10 solar nodes later it shows very smaller amount of improvement for nodes beyond 10. Therefore, it is found that 10 solar nodes are sufficient for the densely placed 100 nodes network scenario. Figure 3c) shows battery consumption reduced as the number of solar nodes increased. Figure 3d) shows energy consumed per transmission or round, where it remains constant throughout the network lifetime because in this there is no variation in CH selection, only solar powered nodes becomes the CH. Whereas the energy consumption per transmission is slightly increase with no. of solar powered nodes which is because of improvement in system lifetime. Figure 3e) and figure 3f) shows the same relation between the no. of packets to CH and no. of packets to BS. Figure 4a) and figure 4b) shows system lifetime improvement from 5 solar nodes to 10 solar nodes drastically but very less improvement after 10 solar nodes as again 10 nodes are enough as a cluster head for a network of 100 nodes. Figure 4c) and figure 4d) exhibit the same relation for energy consumption as it is for modified distributed A-sLEACH. Figure 4e) and figure 4f) shows the no. of packets to CH which are more than packets to BS respectively. Figure 5 shows the comparative performance analysis of distributed LEACH, modified distributed sLEACH, modified distributed A-sLEACH and modified distributed IS-LEACH for 10 solar nodes as 10 nodes are enough for later two protocols. In modified distributed sLEACH, solar nodes are selected as CHs with higher probability on the basis of real time metrological solar data which enhances the performance of the sLEACH than simple LEACH.

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In modified distributed A-sLECAH and modified distributed IS-LEACH, only solar powered nodes become CHs, hence this causes the superior performance of the modified A-s-LEACH and modified IS-LEACH than modified sLEACH and LEACH as shown in figure 5a) and 5b). Further, TDMA scheduling and bringing idle state nodes in the sleeping mode decreases the energy consumption Because of use of non-persistent CSMA protocol for minimization of waiting state and collision avoidance, TDMA for scheduling and data aggregation causes the improvement in performance of network. Battery consumption and energy consumption per transmission is also reduced for modified distributed A-sLEACH and modified distributed IS-LEACH as compared to modified s-LEACH and LEACH.
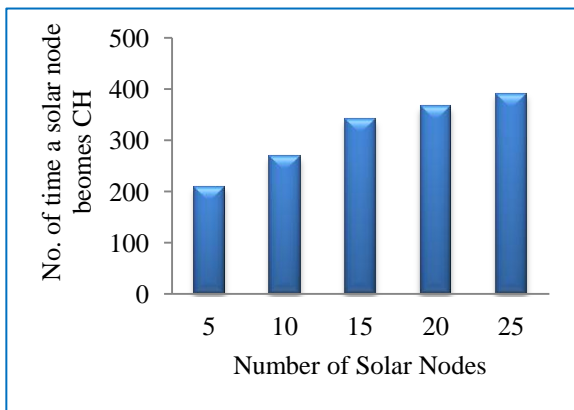

Figure 6. Plot of number of solar node vs number of time a solar node becomes CH.

Increasing the number of solar nodes, increases the probability of selection of solar node as CH as shown in figure 6 for modified s-LEACH.

Figure 7 shows the improvement of modified distributed s-LEACH using real time solar data over centralized and distributed s-LEACH as published in [10]. The figure shows the comparison for half of the nodes runs out of energy. The network lifetime according to the number of round at which first, half node and last node is dead for the different algorithm is shown in table 2 for 10 solar nodes for different initial energy. The proposed modified distributed sLEACH, A-sLEACH and IS-LEACH using real time solar data shows 43.80 %, 66.68 %, 67.19 % improvement in network lifetime respectively for the last node dead.
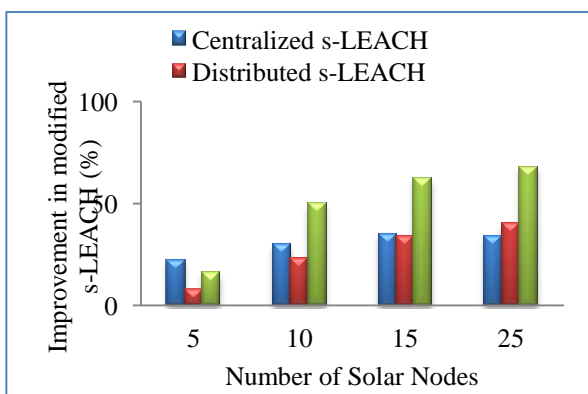

Figure 7. Improvement over centralized and distributed s-LEACH

Table 2. Network lifetime of modified sLEACH, A-sLEACH, and IS-LEACH

Energy (J/node)	Protocol	Round first node dies	Round half node dies	Round last node dies
0.25J	LEACH	395.6	553.4	833.6
	Modified sLEACH	539.4	1148	1483.2
	Modified A-sLEACH	1952.4	2338	2444.6
	Modified IS-LEACH	1778.6	2381.2	2520
05J	LEACH	849.8	1084	1632.4
	Modified sLEACH	1192.6	2211.8	2918.4
	Modified A-sLEACH	3915.8	4644.8	4978.4
	Modified IS-LEACH	3570.4	4807	5016
1J	LEACH	1725	2117	3279
	Modified sLEACH	2298.8	4487.2	5808
	Modified A-sLEACH	7716.6	9441.6	9921.6
	Modified IS-LEACH	7055.4	9603.8	10003.2

V. CONCLUSIONS AND FUTURE SCOPE

Thus in this paper, we have presented the modified distributed sLEACH, A-sLEACH, and IS-LEACH in which solar operated nodes are selected using real time meteorological data. The performance of the system is compared on the basis of network lifetime, battery consumption and packet transmission towards CH and BS. In modified protocols the nodes which are in idle state are bought in to the sleeping mode to minimize the energy consumption which further improves the performance of the system compared to the LEACH, sLEACH and A-sLEACH.

Though performance of the solar aware LEACH is excellent in day time it is having poor performance in the night time, shadow region and rainy season. Out future scope consists of use of alternate renewable energy source for the sensor node which enhances the performance of the network in the night time, shadow region and rainy season.

REFERENCES

1. K. Sohraby, D. Minoli and T. Znati, "Wireless sensor networks: technology, protocols, and applications," John Wiley & Sons, 2007.
2. K. Pavai, A. Sivagami and D. Sridharan, "Study of Routing Protocols in Wireless Sensor Networks," 2009 International Conference on Advances in Computing, Control, and Telecommunication Technologies, Trivandrum, Kerala, 2009, pp. 522-525.
3. D. Goyal and M. R. Tripathy, "Routing Protocols in Wireless Sensor Networks: A Survey," 2012 Second International Conference on Advanced Computing & Communication Technologies, Rohtak, Haryana, 2012, pp. 474-480.
4. S. Misra and R. Kumar, "A literature survey on various clustering approaches in wireless sensor network," 2016 2nd International Conference on Communication Control and Intelligent Systems (CCIS), Mathura, 2016, pp. 18-22.

5. S. Mishra, R. Bano, S. Kumar and V. Dixit, "A literature survey on routing protocol in wireless sensor network," 2017 International Conference on Innovations in Information, Embedded and Communication Systems (ICIIECS), Coimbatore, 2017, pp. 1-4. HwaiyuGeng, "WIRELESS SENSOR NETWORKS," in Internet of Things and Data Analytics Handbook , Wiley, 2017, pp. 201-218.
6. NomanShabbir and Syed Rizwan Hassan, "Routing Protocols for Wireless Sensor Networks (WSNs), Wireless Sensor Networks - Insights and Innovations," Philip Sallis, IntechOpen, DOI: 10.5772/intechopen.70208, October 4th 2017.
7. W. Heinzelman, A. Chandrakasan, and H. Balakrishnan, "Energy-efficient routing protocols for wireless microsensor networks," in Proc. 33rdHawaii Int. Conf. SystemSciences(HICSS), Maui, HI,Jan. 2000.
8. W. B. Heinzelman, A. P. Chandrakasan, and H. Balakrishnan,``An application-speci_c protocol architecture for wireless microsensor networks," IEEE Trans. Wireless Commun., vol. 1, no. 4, pp. 660_670, Oct. 2002.
9. Thiemo Voigt, Hartmut Ritter, Jochen Schiller, Adam Dunkels, and Juan Alonso, ". Solar-aware Clustering in Wireless Sensor Networks", In Proceedings of the Ninth IEEE Symposium on Computers and Communications, June 2004.
10. Rajashree.V.Biradar, Dr.S.R. Sawant, Dr. R. R. Mudholkar , Dr. V.C .Patil "Multihop Routing In Self-Organizing Wireless Sensor Networks" IJCSI International Journal of Computer Science Issues, Vol. 8, Issue 1, January 2011.
11. Do-Seong Kim, Yeong-Jee Chung, "Self-Organization Routing Protocol Supporting Mobile Nodes for Wireless Sensor Network", IEEE2008.
12. S. Lindsey, C. Raghavendra, "PEGASIS: Power-Efficient Gathering in Sensor Information Systems," IEEE Aerospace Conference Proceedings, 2002, Vol. 3, 9-16 pp. 1125-1130.
13. W. R. Heinzelman, A. Chandrakasan, H. Balakrishnan, "Energy Efficient Communication Protocol for Wireless Microsensor Networks," in Proceedings of the 33rd annual Hawaii international conference on System Sciences, Miami, Hawaii, pp. 1-10, 2000.
14. A. Depedri, A. Zanella, R. Verdone, "An Energy efficient protocol for wireless sensor networks," Autonomous Intelligent Networks and Systems (AINS), Menlo Park, CA, PP. 1-6, 2003.
15. L. Lijun, W. Hongtao, C. Peng, "Discuss in round rotation policy of hierarchical route in wireless sensor networks," in International Conference on Wireless Communications, Networking and Mobile Computing, pp. 1-5, 2006.
16. V. Loscri, G. Morabito, S. Marano, "A Two-Levels Hierarchy for Low-Energy Adaptive Clustering Hierarchy (TL-LEACH)," In IEEE Vehicular Technology Conference, Vol. 62, No. 3, pp. 1809- 1813, 2005.
17. M. Islam, M. Islam, M. Islam, "A-sleach: An Advanced solar aware leach protocol for energy efficent routing in wireless sensor neyworks," In ICN, p. 4-9, 2007.
18. H. Junping, J. Yuhui, D. Liang, "A time-based cluster-head selection algorithm for LEACH," in IEEE Symposium on Computers and Communications, pp. 1172-1176, 2008.
19. J. Hee-jin, N. Choon-Sung, J. Yi-Seok, Dong-Reyol, "A mobile agent based leach in wireless sensor networks," in 10th International Conference on Advanced Communication Technology, pp. 75-78, 2008.
20. Khalid M. Al-Smoul, Thamer A. Al-Rawashdeh, Ali A. Al-Dahoud, "An Improved Solar Low Energy Adaptive Clustering Hierarchy (IS-LEACH) Technique," International Journal of Communication Networks and Information Security (IJCNIS), Vol. 8, No. 3, December 2016, pp.221-227.
21. Zhongsheng Guo, "Daily Variation Law of Solar Radiation Flux Density Incident on the Horizontal Surface," Journal of Earth Science and Climate Change, 2017, pp.8-9.

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