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MAXIMIZE THE LIFE SPAN OF WSN WITH MAXIMUM POWER ASSORTMENT ALGORITHM

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Abstract

Wireless Sensor Network is the network of sensor nodes which are worked in a network and gathered the data from the outer world for the proper and complex decision network making. According to the history of wireless sensor network it is depend upon the lots of factors but power is the main factor out of all. The performance of WSN is directly related to the lifespan of the network so as a research point of view power consumption is the important factor in WSN. To reduce the power consumption of the communication some of the traditional and new protocol exist in this field like LEACH, Modern LEACH. This manuscript also introduces a new fixed clustering routing algorithm for WSNs that selects the maximum set level of consumption. This new algorithm overcome some of the problems of LEACH and Modern LEACH. The Maximum Power Assortment Algorithm (MPAA) is reduce the power consumption in communication and improve the network lifetime as compare to these two existing protocols with some parameter metrics like Number of Dead Nodes, Remaining Power, Throughputs, delay and Active Nodes in the network. These parameters provide the significant results for the improvement in network lifetime of the network.

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1. Introduction

Wireless Sensor Networks (WSN) can collect aggregated information and communications from the surrounding area by employing a variety of radio-enabled sensors. The marker, the data collector, the activity data, and the voice go via the node until they reach the Base Station, where they are completed by capturing environmental occurrences in the correct row.

WSNs are being used more and more in essential applications such as intelligent environment monitoring, field control, and passenger traffic monitoring. Routing protocols are classified into three types based on how nodes communicate with one another: direct-to-speech protocols, multicast transmission, and clustering. Through direct submission, each sensor transmits oral data to remote recipients [1].

As a result, the sensor cores no longer need to communicate verbally. Each touch node sends its goods to distant recipients by employing hop to hop communication with other sensors in the network. The cluster head (CH) is in charge of transmitting all data received by the cluster's nodes. Before transferring statistics to the Base Station, CH can combine and compress them. Even though clustering has been proved to be an effective and scalable method of managing WSN, despite of that cluster head consumes the more power than the normal sensor node [2].

LEACH is one of the most widely utilised Cluster Based Routing Protocols for Wireless Sensor Networks (Low Power Efficiency Clustering Hierarchy). LEACH's initial step is setup, and its second phase is steady state. During the tuning phase, some network nodes were chosen at random to become Cluster Heads. Because the node has been identified as a Cluster Head, it sends a profile message including information specific to the Cluster Head's needs. After the Cluster Head is posted, the remaining members join the cluster by locating the nearest Cluster Head. Clusters receive a record and transfer these records of a safe Cluster Head in a staged manner. The Cluster Head synchronises this data and transmits it to the Base Station [3]. When compared to direct conduction or multi-hop routing, LEACH protocols can save a lot of power.

The Topology would be modified at random in the LEACH protocol. The selection of a new Cluster Head and the formation of new clusters for each round consume a lot of energy and contribute to the community's costs [4].

Other LEACH-based methods suffer from the same issue. MPAA not only decreases regular power damage, but it also helps the node survive the cycle. MPAA chooses the node with the most aggregate power using a defined Cluster Head selection method. MPAA employs a set cluster approach rather than altering the Cluster Head for each round.

The results of this manuscript reveal that MPAA can save a significant amount of energy. The MPAA is compared against the LEACH and Modern LEACH Protocols to see how well it performs. While Section III covers the proposed algorithm, Section IV covers the simulation parameters and general comparison of the MPAA implementation with other algorithms. Section V concludes with a conclusion and then moves on to future work.

2. Related Work

In this manuscript, related work shows that various researchers and various labs research keep their work-centric to power proficient working algorithms. All this research mostly focused on to reducing the utilization of power consumption in various activities during communication [5]. In this series of research, various algorithms also suffer from this problem of power consumption and its utilization.

J. M. Kim [6] et al. discuss the strategy used in this manuscript to improve the throughput of the LEACH protocol which is based upon the cluster head selection. According to this manuscript, it improves the cluster head selection strategy than the old traditional strategies. Several strategies are used in past fir this selection process but improvement in the throughput is not significant. The authors of this manuscript uses the fuzzy-based system for the improvement in cluster head selection strategy. When the selection of cluster head is based on the Fuzzy system then it selects the node which has the maximum power than the other node in the network. The selected cluster head performs the communication process between the source and the destination and other activities of the network like path setup and retransmission. The power used in the cluster head selection in this manuscript is less than the other strategies so it improves the lifespan of the network significantly.

Manish [7] et al., discuss the power consumption problem of this network.

Which played the significant role in the network performance. For this it introduces two techniques in this manuscript. The author describes the backpressure and wireless power transmission technique to resolve the problem of power in the network. According to the backpressure technique if some error occurred in the communication process then the node at which this error occurred to inform the immediate previous node of the communication route so that if possible the error would be resolved at the node end and reduce the chances of retransmission. If the retransmission process is controlled in the network activities, then it saves the good percentage of network power. In the next technique, the node of the network is wirelessly recharged with the help of wireless power transmission so that the limited power problem of the network gets resolved. This paper expanded the noteworthy lifetime of the system. Connection usage, course upkeep and decrease overhead is the principal target of this paper.

Manish [8] et al., describe the problem of the network in which some of the nodes communicate the same information in the network at the same point of time. This create the unnecessary redundancy problem. Management of this data in the network is also the important issue because unnecessary data may cause the interrupted action and create the power consumption problem. This is happening due to in such a network every action consume power and it is limited in such network because of battery power. This problem initiates the lots of data transfer in the network and this process consume the power. To manage this power consumption problem, author utilize the ideal hand-off hubs determination method in CC organize and with the assistance of this strategy. With the help of this method, the power utilization in the network gets manage and this will improve the throughput and network lifetime. This can be understanding with such a steps that the unnecessary data could be managed successfully so it saves the power consumption used in management of data in the network. Overloading of redundant data in the network also cause the link breakage at the time of communication, create confusion for data preparation, conflicts in updated data communication which cause the proper decision making in the network. At present some distance issues are with this concept as to transfer this wireless power to the long distance is a challenge according to present concept and technology. Future research on this concept will be keep this issue in mind so that is this issue is resolved than this technology played the important role for resolve the problem of power in such network.

S. Nikoletseas [9] et al., describe the new era technique of wireless power transmission between the source and destination. This manuscript gives the wireless power transmission overview and the way by which wireless power transmission is possible between the source and destination. It works on the two scenarios first is to transfer the power from one point to another point or we can say that from one device to another with the help of magnetic resonance concept. This concept work with the help of conductor coils which are situated at both the ends one at sender and one at receiver side. These coils are made up of metals which are good conductor of electricity. These coils are having some proper and fixed arrangement of curves by which these are able to generate the magnetic power so that proper current is induced in the secondary coil. The load which is connected to this load can able to work properly with this current. This transmission is possible only when both devices or coil of that device are resonant at the same frequency so that power can be transferred efficiently. This power transmission technique is non-radiative in nature. In the second scenario keep track of charges transferred at the device. This calculation is important for the continuous transmission of power between the source and destination load. Manuscript assesses the outcomes with continuously condition.

B. M. Makaa [10] et al., describe the technology used by the tesla for proven of wireless power transmission. This transmission is performing with the help of a magnetic resonance concept. This magnetic resonance concept is very important and safe method. This method is non-radiative in nature so that the waves transmission is not affect the outer world like human being. For this transmission, tesla coils are used in which flow of current produce the electromagnetic waves and these waves can be transferred to another coil with the help of the tunneling method. In that case power of wave can be transferred in a unique and single frequency. As the behavior of the waves are spreading in the environment which reduce the impact of these with respect to distance from the source. But in this case when these wave are transferred with tunneling method it can travel with unique way and because of that maximum power is transmit from one point to another. As per the outcomes, this paper shows that tesla loops are exceptionally fit for producing high voltage, high-recurrence waveforms. It additionally shows that tesla loops are intended for remote force move. This manuscript provides the technique for new future. This concept of magnetic resonance is the future concept for the flow of electricity in wireless environment.

X. Lu [11] et al., describe the concept of wireless power transmission and related issue of this technology. These issues are very crucial importance in the successful implementation of such wireless transmission of power concept. With the help of this technology power can be transferred from one point to another point with some distance. As this concept is new for this era so various issues are in the picture for the implementation of wireless power transmission. The main issues for such implementation of such technology is distance covered by such transmission and this transmission is effect on the human beings and other effects etc. Various methods are used to implement this technology but some of them are non-radiative in nature so that it can't harm the human being body at the time of transmission of power. This concept has lots of opportunities so that most of the businesses applied this concept to save lots of power and utilize this idea for remote charging. It shows the remote charging guidelines and most recent system applications which are utilized in the market. It additionally talks about the difficulties of actualizing the remote charging idea. This wireless charging is helpful at various times. This concept is helpful at the time of travelling and when the fixed power supply is not available. When the user in movable condition then this fixed power supply is the problem so at that time this wireless power transmission played the important role to increase the lifetime of battery of the mobile devices.

3. Maximum Power Assortment Algorithm

This is the proposed algorithm for assigning permanent clusters to the WSN, which has not changed during the WSN's history. Each cluster has a Cluster Head who is in charge of receiving and transmitting recorded recordings to a terminal. The MPAA has two levels of operation. The first stage is the limiting stage in which clusters arise, while the second stage is a component of a state that determines the stability of reality. The setup portion is not repeated for each cycle, unlike LEACH and many LEACH-based protocols. This is accomplished by the use of a consistent cluster, which has an impact on total power savings. The Cluster Head was picked at random under MPAA, and the message was then delivered to the other sensors. All of the most recent sensors joined their nearest cluster during the pre-planned phase [12]. The sub-sections that follow provide a thorough overview of the operational stages and the current situation of the MPAA.

A. Initial Phase for Cluster

Begin by distributing sensor nodes, and the methodology will begin the initial phase with the alteration shown in Figure 1. The sensor node can choose whether to be a cluster leader or a regular node in the network. Following that, it broadcast its identity to the network so that other nodes may join its cluster.

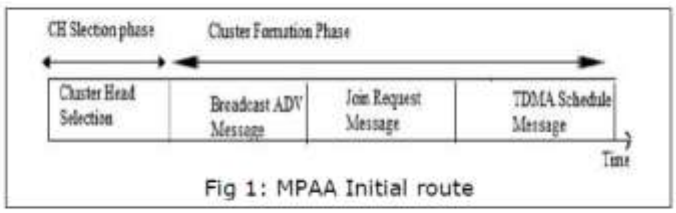

Figure 1. MPAA Initial route.

a. Selection of Head Node

MPAA Cluster has invented a random sensor deployment strategy in which each sensor makes its own decision. Assume that the required number of clusters for this sensor's community is represented as C (the number of clusters) and the amount of sensor as N, and that each node displays the probability for Cluster Head as ProbCH = C/N.

If the chance of any node acting as Cluster Head exceeds ProbCH, that node will be selected as Cluster Head. Otherwise, it functions similarly to the other members of the cluster. The MPAA's principal goal is to exploit the power of the current Cluster Head rather than selecting a new CH unit with the greatest residual power [13]. If the existing Cluster Head is unable to continue, additional cluster nodes can be designated as Cluster Heads.

b. Creating Clusters

Each node designated as a Cluster Head must alert all other nodes in the network of its existence [14]. Following then, the Cluster Head broadcast an advertising message in order to reveal cluster head information via CSMA, and the message also provided the Cluster Head's ID.

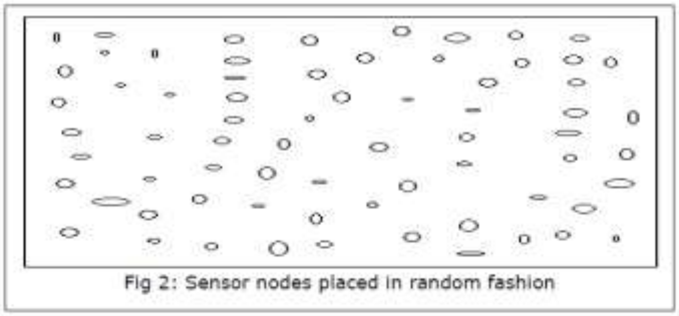

Figure 2. Sensor nodes placed in random fashion.

Ordinary nodes that receive advertising messages can choose to join the cluster with the minimal amount of communication power. Send a join request message to the relevant cluster to join a regular node. The "Request for Join" message contains the identification number of the normal node as well as the Cluster Head to which the node seeks to join.

The Cluster Head, according to the information, organizes a TDMA programme for participants to employ in order to transmit data. The size of the programme is fixed and determined by the number of nodes in each cluster.

The steady-state phase of communication will commence once the cluster's nodes have finished the schedule set-up phase [15]. Figure 2 displays the deployment of the sensor node in the network, while Figure 3 depicts cluster formation and cluster heads in the network.

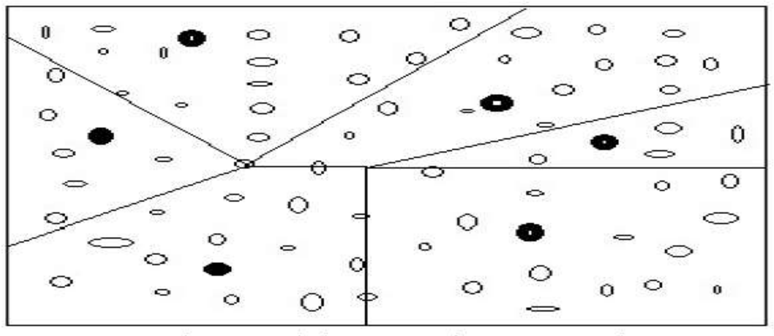

Figure 3. cluster and cluster Head generation phase.

B. Steady-State Phase

During this point, the cluster head commences collecting data from all cluster nodes and sending it to the base station. The cluster head collects data on the remaining power of the cluster's nodes at each round since this data is used to select the cluster's next cluster head. This phase is always in an active state with the MPAA algorithm and works for the whole lifecycle of the network's nodes. Figure 4 depicts the MPAA algorithm cycle. This lifecycle is separated into two parts: one in which data transmission occurs and the other in which a decision to replace a cluster head is taken.

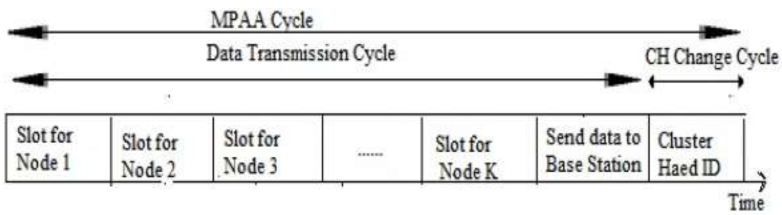

Figure 4. MPAA Cycle.

a. Data Transmission Cycle

In this portion of the document, the sensed data acquired by the cluster nodes is transferred to the cluster head and then to the base station. The transmission slot for each node is fixed and determined by the number of nodes in the cluster.

According to the foregoing description, each node has a limited time window for data transmission during which all other nodes are in sleep mode.

This phase prevents a collision between the nodes, reducing the resources required to manage the collision and retransmission. The cluster head transferred all data from all nodes to the network's base station after gathering it from all nodes.

b. Cluster Head Replacement Cycle

The MPAA approach makes use of fixed clusters, which means that no node in the cluster has the ability to change the cluster's whole lifecycle.

When the power level of the cluster head falls below the threshold power level, the cluster head is replaced. At the end of each Data Transmission cycle, the cluster head must determine whether it can continue to serve as the cluster head or whether it must be replaced by a high-level power node in the cluster. The cluster head threshold value must be changed, and this value must be properly evaluated because it is accountable for the network's future operations. The threshold value was carefully calibrated in order to make the most use of network power.

The simulation approach is used in this manuscript to calculate the impact of the threshold value on the MPAA algorithm. In the proposed approach, at the time of data transmission, the cluster head collects the remaining power of the nodes so that it can decide whether or not to replace the cluster head.

If the (Remaining power Threshold value) situation occurs, the existing cluster head must be replaced with a new high power node and the new cluster ID must be changed in the MPAA Cycle. However, if this requirement is not met, the current Cluster ID is kept in this field. The remaining power of the sensor nodes that is less than the threshold value is transferred to the current cluster head, allowing the present cluster's power level to be maintained and its lifetime to be extended. This procedure also improves the network's overall power utilisation. This transmission is made feasible by a transmission coil coupled to each sensor node.

4. Simulation Parameter and Results

Table 1 covered all the simulation parameters used in this simulation.

Table I. Simulation parameters.

Parameter	Value
Initial Power(each node)	2 joule
Packet dimension	6400 bits
Transceiver Power (Eelec)	50nJ/bit
Nodes for Simulations	80, 100
Root Station parameters	(450, 250)
Network Area	500*500
No. of step(each algorithm)	80
Protocols	MPAA, LEACH, Modern LEACH
Simulator	MATLAB

For the performance evaluation of all three methods, this publication employs a variety of parameters metrics. Metrics for parameters include the number of dead nodes based on threshold power, active nodes, remaining power, throughput, and delay.

a. The Effect of Threshold Value

Figure 5 shows a graphical representation of the number of dead nodes in three protocols with varying Threshold values: MPAA, LEACH, and Modern LEACH. The graph below illustrates that the number of dead nodes is about the same for the initial threshold values, but as the threshold value increases, so does the difference in the number of dead nodes. LEACH and Modern LEACH have less dead nodes than the MPAA.

The proposed MPAA algorithm has fewer dead nodes throughout the simulation phase. This particular outcome is directly tied to network performance. Because the suggested technique results in a lower number of dead nodes (about 5%), the network's lifetime improves directly.

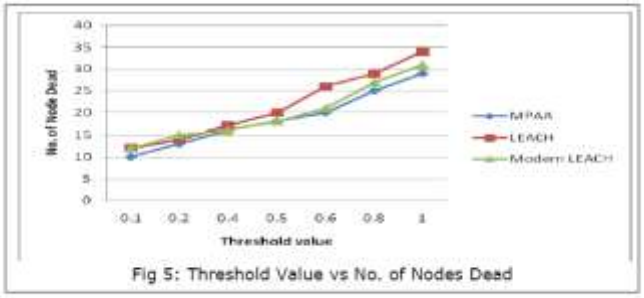

Figure 5. Threshold Value vs No. of Nodes Dead.

b. System Cycle Time

Figure 6 shows a graphical representation of the number of active nodes remaining in the network as the number of network cycles increases.

According to earlier observations, the MPAA Threshold value in this paper is 1/40 of the starting energy of nodes. According to the graph results, MPAA is 64% better than LEACH and 58% better than Modern LEACH. According to the results, MPAA meets all of the parameter metrics.

The main distinction between different protocols and the MPAA is as follows: Rest node death occurs extremely quickly following the death of the first node LEACH and Modern LEACH. However, with MPAA, node death is equally distributed during network life.

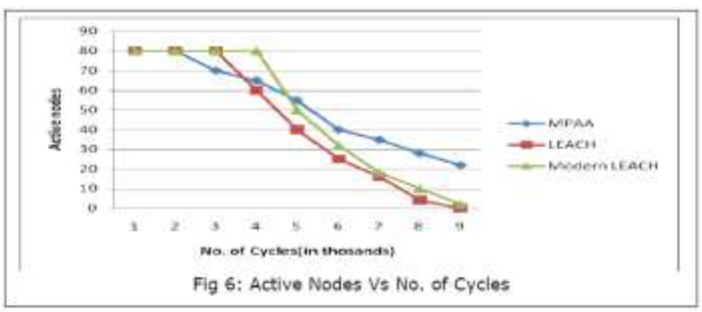

Figure 6. Active Nodes Vs No. of Cycles.

c. Remaining Power

Figure 7 shows a graphical representation of the node's remaining power in the network as a function of the number of cycles. The remaining power is the power that remains after the network has completed one successful cycle.

All three procedures begin with the same power, and as the number of cycles grows, the power decreases. After the number of cycles, this graph demonstrates that MPAA has 25% more power than LEACH and Modern LEACH.

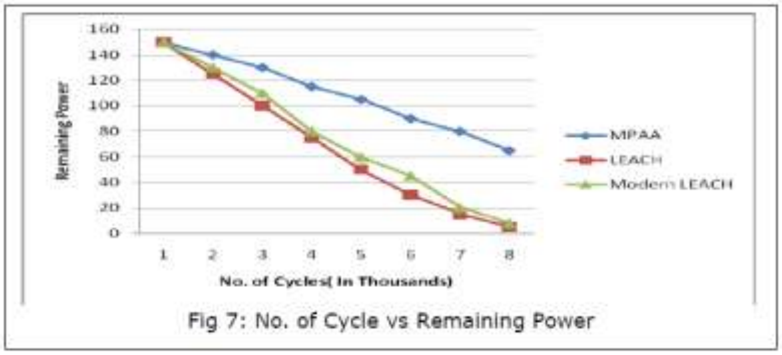

Figure 7. No. of Cycle vs Remaining Power.

d. Throughput

Figure 8 depicts a line graph of the network's processing capacity and cycle count. The graph shows that the initial throughput of all three protocols is the same, but as the sampling rate increases, so does the disparity in throughput. The throughput of both standard protocols is roughly identical up to cycle number four, but the graph reveals that the MPAA generates greater throughput.

MPAA outperforms LEACH and Modern LEACH in terms of throughput. It is around 10-15% higher than the rest of both procedures. These results are obtained through several simulation processes, and the final outputs are the average of all simulation outcomes.

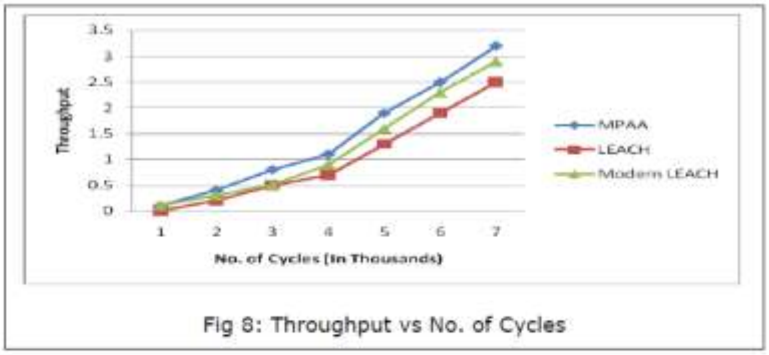

Figure 8. Throughput vs No. of Cycles.

Figure 9 shows a graphical representation of the overall delay and number of cycles. This delay occurs between the start of communication on the source side and the successful reception of a data packet on the receiver side. Congestion, route blockage, intermediate node delays, and some real-time difficulties can all cause delays.

According to the graph data, all three protocols offer the whole delay for each and every cycle. According to the graph below, all three protocols are at the same level of delay at the start of communication, with only a slight variance. In the middle of the transmission, bot LEACH and modern LEACH produce nearly identical results with just minor differences, however in the case of the suggested protocol, MPAA provides less delay than both other protocols. At the completion of the communication process, all three methods produce about the same latency. At this point, the difference in delay is negligible. According to the results, in terms of overall latency, the proposed protocols give 8-10% less delay than the other two protocols, LEACH and Modern LEACH.

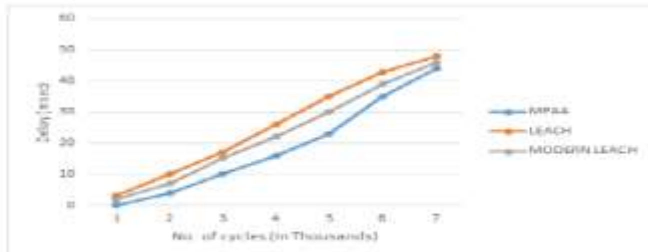

Fig 9: Delay(msec) Vs No. of Cycle

Figure 9. Delay(msec) Vs No. of Cycle.

5. Conclusion and Future Work

The Wireless Sensor Network is a network made up of multiple sensor nodes that collect data from the outside world and send it to the base station. The performance of a wireless sensor network is determined by a variety of elements, the most important of which is the lifetime of the network's sensors. When conducting research on sensor networks, this power issue should be at the forefront of the investigation. Such a network is solely portable, therefore it runs on battery power and is therefore limited in nature. This issue is always the main issue of such network due to the limited addition of such electricity. One new Algorithm is proposed in this manuscript. The proposed MPAA approach saves roughly 15% of the power consumed by the hubs or network. It reduces the network overhead associated with cluster head replacement and data retransmission. This saves a lot of electricity in terms of residual power and extends the network's system lifetime.

The MPAA algorithm improves network performance by 10-15% over LEACH and Modern LEACH. It decreases the time between communication processes by over 5%, saving significant power usage in the network. Future elements of this manuscript include the cluster's greatest distance from the base station and the maximum utilisation of sleep mode.

References

[1] F. Ren, J. Zhang, T. He, C. Lin and S. K. Das, EBRP: Energy-Balanced routing protocol for data gathering in wireless sensor networks, IEEE Transactions On Parallel and Distributed Systems 22(12) (2011).

[2] L. He, Delay-Minimum Energy-Aware routing protocol (DERP) for wireless sensor networks, IEEE Eighth ACIS International Conference on Software Engineering, Artificial Intelligence, Networking and Parallel/Distributed Computing, (2007).

[3] X. Wu, G. Chen and S. K. Das, Avoiding energy holes in wireless sensor networks with non-uniform node distribution, Parallel and Distributed Systems, IEEE Transactions 19(5) (2008), 710-720.

[4] M. Bhardwaj and A. Ahlawat, Reduce energy consumption in Ad hoc network with wireless power transfer concept, International Journal of Control Theory and Applications 10(13) (2017).

[5] M. Bhardwaj and A. Bansal, Energy conservation in mobile Ad Hoc network using energy efficient scheme and magnetic resonance, advances in networks, Special Issue: Secure Networks and Communications 3(3-1) (2015), 34-39.

[6] M.T. Chung, J.Y. Han, M. J. Kim and H. S. Park, CHEF: cluster head election mechanism using fuzzy logic in wireless sensor networks, Proc. of ICACT, (2008), 654-659.

[7] M. Bhardwaj, Enhance life Time of Mobile Ad hoc Network using WiTriCity and Backpressure Technique, 1877-0509 © 2015 The Authors, Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license, (2015). doi:10.1016/j.procs.2015.07.447

[8] M. Bhardwaj, Selection of efficient relay for energy-efficient cooperative ad hoc networks, American Journal of Networks and Communications, Special Issue: Ad Hoc Networks 4(3-1) (2015), 5-11. doi:10.11648/j.ajnc.s.2015040301.12

[9] S. Nikoletseas, An experimental evaluation of wireless power transfer protocols in mobile ad hoc networks, IEEE Wireless Power Transfer Conference (WPTC) (2015), 1-3.

[10] M. B. Makaa, Analysis of WPT system using rearranged indirect-fed method for mobile applications, IEEE Wireless Power Transfer Conference (WPTC) (2015), 1-4.

[11] Z. Han, I. D. Kim, X. Lu, D. Niyato and P. Wang, Wireless Charging Technologies: Fundamentals Standards and Network Applications, Communications Surveys and Tutorials IEEE 18, ISSN 1553-877X (2016), 1413-1452.

[12] M. Bhardwaj, A. Pathak and B. K. Saraswat, Optimum Experimental Results of AODV, DSDV and DSR Routing Protocol in Grid Environment, Procedia computer science, 3rd International Conference on Recent Trends in Computing 2015 (ICRTC-2015) 57 (2015), 1342-1350. doi:10.1016/j.procs.2015.07.451

[13] M. Bhardwaj and A. Singh, Power Management of Ad Hoc Routing Protocols Using Mobility Impact and Magnetic Resonance, Advances in Networks, Special Issue: Secure Networks and Communications 3(3-1) (2015), 27-33. doi:10.11648/j.net.s.2015030301.14

[14] S. Nikoletseas, P. T. Raptis and C. Raptopoulos, Interactive Wireless Charging for Energy Balance, Distributed Computing Systems (ICDCS), IEEE 36th International Conference on, ISSN 1063-6927 (2016), 262-270.

[15] Giuseppe Anastasi, Marco Conti, Mario Di Francesco and Andrea Passarella, Energy conservation in wireless sensor networks: A survey, Ad Hoc Networks 7(3) (2009), 537-568.

[16] Chang-Soo Ok, Seokcheon Lee, Prasenjit Mitra and Soundar Kumara, Distributed power balanced routing for wireless sensor networks, Computer and Industrial Engineering 57(1) (2009), 125-135.

[17] D. Azzi, V. Kanakaris and D. Ndzi, Ad-Hoc networks energy consumption: A review of the Ad Hoc routing protocols, Journal of Engineering and Technology, Review 3(1) (2010), 162-167.

[18] H. Huang, G. Hu and F. Yu, A routing algorithm based on cross-layer power control in wireless Ad Hoc networks, Communications and Networking in China (CHINACOM), (2010).

[19] R. Ghanbarzadeh and R. M. Meybodi, Reducing message overhead of AODV routing protocol in urban area by using link availability prediction, Second International Conference on Computer Research and Development, (2010).

[20] Mohammed Ali Hussain et al., Energy conservation techniques in Ad Hoc networks, IJCSIT International Journal of Computer Science and Information Technologies 2(3) (2011), 1182-1186.

[21] S. P. Karadge and V. S. Sankpal, A performance comparison of energy efficient AODV protocols in mobile Ad hoc networks, International Journal of Advanced Research in Computer and Communication Engineering 2(1) (2013).

[22] B. Cousin, Z. Mekkakia and O. Smail, Energy efficiency in ad hoc wireless networks with node-disjoint path routing, 7th Int. IEEE Workshop Systems Signal Processing and their Applications (WOSSPA) (2011), 127-130.

[23] C. Kumar, N. A. Petra and K. D. Sharma, An update based energy-efficient reactive routing protocol for mobile Ad Hoc networks, I. J. Computer Network and Information Security 11 (2013), 17-26.