ISSN 2250-3153

A Survey on "Energy Efficient Routing Techniques in Wireless Sensor Networks Focusing On Hierarchical Network Routing Protocols"

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Abstract- Wireless Sensor Networks have an extensive range of applications but they are conquered with many challenging problems and complications that need to be addressed. The energy consumption of the nodes and the extension of the network lifetime are the core challenges and the most significant features of the routing protocol in order to make it suitable, effective and efficient for WSNs. As the sensor nodes are basically battery powered devices, so the top concern is always to how to reduce the energy utilization to extend its lifetime. In the past few years WSNs has gained a considerable amount of attention from both the research community and the real users. The researchers also proposed many different energy efficient routing protocols to achieve the desired network operations. In this paper there is an attempt to give a wide comparison of the routing protocols in WSNs focusing on the hierarchical or clustering based routing protocols. Moreover, extracting the strengths and weaknesses of each protocol, providing a comparison among them, including some metrics like scalability, mobility, power usage, robustness etc. to make it understandable and simple to select the most suitable one as per the requirement of the network.

Index Terms- Wireless Sensor Networks, Routing Protocols, Sensor nodes, Energy Efficiency, Power Management

I. Introduction

Wireless Sensor Networks (WSNs) brought a dramatic variation in bringing advancement in technologies and also providing opportunities for effective usage of resources in critical environments [2]. WSNs are basically the collection of wireless nodes having limited energy capabilities, are deployed randomly over a dynamically changing atmosphere, may be mobile or stationary, for observing physical phenomena like humidity, temperature, health monitoring, vibrations, seismic events etc. [4][5]. Selecting a routing strategy is the core issue for gathering and delivering the efficient packets of useful information to the specified destination. So the routing strategy should guarantee the least energy consumption resulting in maximizing the network's lifetime [6].

The WSNs may be used in the variety of everyday life activities or services. For example its common use is for monitoring like in Military to detect enemy intrusion or monitoring the air pollution or to be used for forest fire detection to control when a fire has started. In addition, an important area of use is the healthcare sector. Moreover, the use of WSNs on agriculture may benefit the industry frees the farmer from the maintenance and wiring in a difficult environment [5].

A sensor node is typically an ultra-small limited power device that consists of four basic components. First is the sensing part for data acquisition, then the control system for the local data processing and memory operations (storage), then a communication subsystem for transmission and reception of data from other linked devices and finally a power source that supplies the required energy for performing the desired tasks [1][3]. This power source usually comprises of a battery with limited energy so if a critical node stops working then it's a big and serious protocol failure. The main thing is that it could be impossible to recharge the battery because the nodes are deployed and spread randomly in a hostile environment or any other area of interest such as unapproachable areas or the disaster locations for getting the required information. So to fulfil the scenario requirements the sensor nodes should have enough and prolonged life time, even in some cases up to several months or years can be required. So the question arises that "how to elongate the lifetime of the node for such a long duration" [2][3].

It is also possible to use the energy from the external environment e.g. using the solar cells as a power source [7]. But usually a non-continuous behavior is usually observed from the external power sources so some energy buffer is also needed. Whatever is the situation; energy is a serious resource and should be used very carefully. So what is clear from it is that energy is a main issue for the systems grounded on WSNs.

The distributed protocols can be a good solution in handling the failures more efficiently. Clustering based routing protocols which are designed for the energy efficiency of a network are capable of data aggregation [2]. Delay can be easily reduced because with in a cluster the localized algorithms can function without the wait of the control messages. So as compared with the centralized ones the localized algorithms can achieve more stability and throughput. In clustering certain nodes are selected as Cluster Heads (CHs) which had to spent more energy than rest of the nodes for a specific time frame. The information from the sensor nodes is accelerated to CHs and then these CHs are responsible to handover the information to the base station (BS) which is placed far apart from the field. Many cluster based protocols like LEACH [8][14], LEACH-C [9][15], PEGASIS [10], TEEN[11], APTEEN[12], VGA[13] etc. are proposed which enlighten the efficient usage of energy in wireless sensor networks.

This paper is structured as follows: The section 2 enlightens the related work in the surveys of routing protocols in WSNs. In section 3 the Network Lifetime is defined and the vital concept behind any technique used for energy efficient routing. The objective of section 4 is to understand the sources of energy waste in WSNs. In section 5, I described and compared different clustering protocols schemes and showing some of the advantages and disadvantages of them. Finally in section 6, I conclude the paper.

II. RELATED WORK

An enormous number of current works and efforts are on the go, for the advancement of routing protocols in WSNs. These routing protocols are grounded on the application needs and the structure of the network. However, there are some issues that must be taken into consideration while mounting the routing protocols for WSNs. The most important and glittering factor is the energy efficiency of the sensors that directly influence the lifetime of the network. There are numerous surveys and Journals on routing protocols in WSNs and an effort is done to present below and discuss the dissimilarities between them.

In survey [4], the authors explained comprehensively the design problems and techniques for the WSNs (2002). They define the "physical constraints of sensor nodes" and the "proposed protocols" apprehending all layers of the network stack. Other than that the potential applications of sensor networks are also discussed. But the list of discussed protocols in the paper can't give the complete picture and the scope of the survey. My survey is more dedicated to the energy efficiency of WSNs providing the classification of the existing routing hierarchical protocols. I also discussed a number of already developed energy-efficient routing hierarchical protocols and provide guidelines to the readers to select the most suitable protocol for their network.

The [23], is a survey on "routing protocols in WSNs" presented in 2004. Flat, hierarchical, and location-based routing protocols are the three routing techniques classified in this survey based on the structure of the network. These protocols are further classified into "multipath-based, query-based, negotiation based, and QoS-based routing techniques". In total it presents 27 routing protocols. Furthermore, this paper presents a fine number of energy efficient routing protocols which have been established for WSNs. Challenges in routing are also presented and Design Issues are also mentioned in the paper. On the other side, in my work I focused on the energy efficiency issues in WSNs. I provide some details and comparisons on energy efficient protocols that may help researchers on their work to some extent.

The survey in [24] discusses some of the routing protocols for sensor networks and classifies them into "data-centric, hierarchical and location-based "(2005). Although it describes routing protocols for WSNs but it does not focus on the energy efficient policies. On the other side, I mainly focused on the energy-efficient routing hierarchical protocols elaborating the strengths and flaws of each protocol in such a way as to provide directions to the readers to choose the most effective energy-efficient routing hierarchical protocol.

In [25], authors give a "systematical investigation of current state-of-the-art algorithms "(2007). The authors categorize the algorithms in the minimum energy broadcast/multicast problem and the maximum lifetime broadcast/multicast problem in wireless ad hoc networks. Characteristically, the two key energy-aware metrics that are taken in consideration are "minimizing the total transmission power consumption of all nodes involved in the multicast session and maximizing the operation time until the battery depletion of the first node involved in the multicast session".

The survey in [26], shows a "top-down approach "of numerous applications and reviews on many features of WSNs in 2008. It organizes the problems into three different kinds: "internal platform and underlying operating system, communication protocol stack, network services, provisioning, and deployment". But the survey didn't provide a detailed comparison of the protocols. My work is a dedicated study on energy-efficient clustering protocols and provides guidelines to the readers on selecting the most appropriate protocol.

In [27], the authors present a survey that is focused on the energy consumption based on the hardware components of a typical sensor node (2009). They distribute the sensor node into four key components: "a sensing subsystem including one or more sensors for data acquisition, a processing subsystem including a micro-controller and memory for local data processing, a radio subsystem for wireless data communication and a power supply unit". The paper is concentrated on the explanation of the characteristics and benefits of the taxonomy of the energy conservation schemes. The protocols are categorized into "duty-cycling, data-driven and mobility based". In the next protocols, more details and discussion are presented of this classification. Moreover, different approaches to energy management are provided and highlighted. They conclude that "the sampling phase may need a long time especially compared to the time needed for communications".

In [28], the design issues of WSNs and classification of routing protocols are presented (2009). Moreover, a few routing protocols are presented based on their characteristics and the mechanisms they use in order to extend the network lifetime without providing details on each of the described protocols. Also, the authors do not present a direct comparison of the discussed protocols. In our work we do not only focus on the energy-efficient protocols but we also discuss the strengths and weaknesses of each protocol in such a way as to provide directions to the readers on how to choose the most appropriate energy-efficient routing protocol for their network.

The paper [29] enlightens the challenges in the design of the energy-efficient MAC protocols for the WSNs presented in 2009. It describes 12 MAC protocols for the WSNs highlighting their strengths and weaknesses. The paper neither deliberates the energy-efficient routing protocols established on WSNs nor gives a comprehensive comparison of the protocols.

In survey [30], some energy-efficient routing techniques for "Wireless Multimedia Sensor Networks (WMSNs)" are presented in 2011. The authors also focused on the performance matters of each strategy. The design tasks of routing protocols for WMSNs are also highlighted in the paper. Furthermore, taxonomy of current routing protocols for WMSNs is also presented. This survey paper discusses few issues on energy efficiency.

Though, there are decent number of surveys for "sensor networks, or routing and MAC algorithms for WSNs" ([4], [23], [24], [25], [26], [27], [28], [29] and [30]), but this paper gives a brief survey emphasizing on the energy-efficient routing hierarchical protocols in WSNs. My survey is focused on the energy efficient clustering protocols in WSNs that can provide some directions to the readers. Moreover, I also discussed the strengths and weaknesses of each clustering protocol making a comparison between them including some metrics.

III. NETWORK LIFETIME EXPLANATION

Recently, the most thought-provoking concern in "WSN" is how to save the node energy as well maintaining the wanted network performance. Till their being alive, these nodes can perform their work, but after that it will not be possible. Its mean is that the goal of every energy efficient technique is to optimize the life duration of these energy nodes through which the lifetime of the "WSN" will be increased. So its mean, lifetime of the single node, should be increased. In the literature, related to the definitions of network lifetime, there is no absolute consensus, which leading us toward the cluster of definition. Following are some more relevant and common definitions of the network lifetime which are based on the previous work on "WSN" [16], [17]. Different authors describe the network lifetime, based on the different reasons as:

- According to the definition as per literature of the time, when all the nodes are alive also called as "n out of n in [17], where n is the total number of sensors", the network lifetime based on the number of alive nodes. But as per the literature review, on assumption has been found that for the satisfaction of above definition, it's necessary to assume that "sink" nodes are more sophisticated and powerful that's why they should be out of the set of nodes. If the topology changes have been controlled as the external variable in this model of definition, then it will be easy to compute the lifetime of network. In the case of opaque networks, this type of matric does not work as actually the lifetime evaluation. So its means that this matric based on two presumptions as: 1) all nodes are of equal importance, 2) all nodes are critical to network application. One variant describes the lifetime of the network with a minimum threshold β. Its mean that the lifetime of network will be the time till the fraction of an alive node fall below β [18]. The positive side of it is that it reflects the redundancy but not precisely defines the correct assembly of applications, where the failure of at most β% of sensors near the sink can stop the sink to obtain composed data. Literature review showing that many authors have changed the "cluster head" dynamically, to stable the consumption of energy.
- *Some authors define the lifetime of the network based on coverage.*
  Let's firstly define the coverage. Coverage reveals that in the monitored area, how well the network can detect an event. That's why many authors define the lifetime of network as the time during which the senor nodes cover the relevant interest. At one point, it's going to lack the importance that it does not ensure that composed data are delivered to the sunk or not. That's why the 100% efficiency is not sufficient.
- *Definition here is based on not the coverage, but based on the connectivity.*
  It means that the ability to transfer the data to a sink is considered here as the base to define the connectivity. Here the authors [21] describe the time as the least point, when either the %age of "alive nodes" or the size of the main connected component of the network falls below a definite threshold.
- Some authors define the lifetime of network by considering that network is "alive as long as application functionalities are required." Kumar et al. [22] define "we define the lifetime of a WSN to be the time period during which the network continually satisfies the application requirements".Tian and Georganas [18] propose another explanation as "the network no longer provides an acceptable event detection ratio." But to some extent, it becomes irrelevant.

In the summary of the above defined statement, it's obvious that while defining the lifetime of network, the concept of coverage, connectivity, and to some extend the requirements of the application functionalities for "WSN" have to consider. Because the idea of the application requirements will lead the authors to further refine the concept of the lifetime of network. Indeed on the users side, it will lead toward the more accurate and relevant evaluation.

IV. REASONS OF ENERGY WASTE IN WSNs

If have to save the energy then lessening data extracted from transducer is necessary. During the reporting, repetition can be arisen because of the intrinsic redundancy in "WSN". It's true that the communication subsystem is a gluttonous cause of the energy debauchery because in communication, wastage of energy occurred in those states which are useless from the application point of view. Some of them are as follows [16]:

Crash: All the packets will be crashed, when a node obtains more than one pack at the similar time. All packs that grounds the smash have to be castoff and the retransmission of these packs is obligatory.

Overhearing: P.Minet in "Ad Hoc and Sensor Wireless Networks" explains that "when a sender transmits a packet, all nodes in its transmission range receive this packet even if they are not the intended destination. Thus, energy is wasted when a node receives packets that are destined to other nodes."

Control Packet Overhead: To enable data transmission, the minimal number of control packets should be used.
Idle Listening: it's occurred, when a node listens to an idle channel to get probable traffic. It is considered the biggest source of energy wastage.
Interference: P.Minet in "Ad Hoc and Sensor Wireless Networks" explains that "each node located between transmission range and interference range receives a packet but cannot decode it."

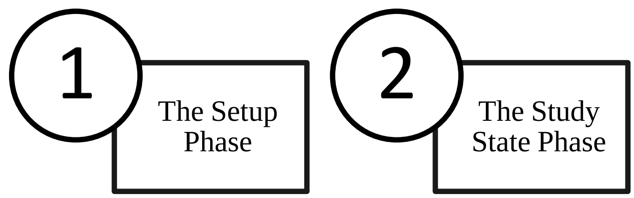
V. HIERARCHICAL NETWORK ROUTING PROTOCOLS

In "Hierarchical Networks" protocols nodes are grouped into the clusters, as compare to flat protocols in which each node has its distinctive universal address and all the nodes are peers. In "Hierarchical Networks", each cluster owns a cluster head, of which election is established on the different election algorithm. Uses of cluster head are: *1) advanced level of communication, 2) decreasing the transportation overhead*. Having the identical level of communication thoughts in each level, the clustering can be drawn-out to the more than just two levels. Indeed, this technique also has a lot of positive points, among all of them, reducing the size of routing tables along with increasing the scalability is very dominant benefit.

LEACH: "Low-Energy Adaptive Clustering Hierarchy":

In this type of hierarchical protocol, most of the nodes communicate to cluster heads (C.H) [8], [14].

"LEACH" consists of two phases:



The Setup Phase: in this phase, the clusters are ordered and then C.H[1] has been selected. The task of C.H is to cumulate, wrapping, and forward the information to the base station (Sink).but question is that how it will be decided, that which node will be C.H? "Stochastic algorithm" will be used in this round of selection. But it will be applied with a condition that, if a node will be C.H, the next time it will not be selected in the "P- Round"[2]. It means that in each round the possibility to become the C.H for each node is 1/P. by doing this a systematic rotation of the nodes in each round leads toward balanced energy consumption by all the nodes and indeed will enhance the lifetime of the network.
The Study State Phase: in the previous state, the nodes and the C.H have been organized, but in the second state of "LEACH", the data is communicated to the base station (Sink). Duration of this phase is longer than the previous state. To minimize the overhead, the duration of this phase has been increased. Each node in the network, contact with the cluster head, and transfer the data to it, after that C.H will develop the schedule to transfer the data of each node to base station. D.A. Vidhale et al describes main advantages of this technique as "it outperforms conventional communication protocols, in terms of energy dissipation, ease of configuration, and system lifetime/quality of the network" As per these advantages, "wireless Distributed protocol" will help pave the way in "WSN". Basically in the "LEACH", the "single hop" routing has been used, in which each node can be transmitted directly to the sink (Base Station). It's a way of dynamic clustering, which help to extra overhead like the advertisements, which leads toward the lessen the addition in energy consumption.

LEACH-C "Low-Energy Adaptive Clustering Hierarchy Centralized:

As compare to the "LEACH", the base station is used to develop the C.H, instead of nodes will be configured themselves into the C.H [15]. How the BS (Base Station) will work in this regard to develop the C.H? Firstly the BS obtains data as per the location & energy level of every node in the network. On the second stage it will find a recent number of C.H and the after that it will be organizes the network into the clusters. It has been completed in respect to curtail the energy, mandatory for non CH nodes to convey their information to their particular cluster heads.
Following are the improvements as compare to "LEACH":

- The BS uses its universal knowledge of the network to create clusters that necessitate less energy for data broadcast.
- In "LEACH-C" the number of C.H in each round equals a prearranged optimum value.

PEGASIS "Power-Efficient Gathering in Sensor Information Systems":

It is a "chain-bases protocol" and an upgrading of the "LEACH" [10]. In "PEGASIS" every node transfers only with a close neighbor to direct and obtain information. It receipts turns communicating to the BS, thus decreasing the quantity of energy consumed per round. The nodes are in this way that a chain should be developed, which can be completed by the sensor nodes along with using an algorithm. On the other hand, the BS can compute this chain and transmission of it to all the sensor nodes.

In the simulation, it is completed in a system that has 100 situated nodes but randomly. The BS is located at a distant distance from all the remaining nodes. Thus, for "a 50m x 50m plot", the BS is situated at "(25, 150)" so that the BS is at least "100m" remote away

[1] C.H means the Cluster Head.
[2] "Where P is the desired percentage of cluster heads".

from the neighboring sensor node. To develop the chain, it is expected that all nodes have universal information of the system and that a greedy algorithm is engaged. Thus, the structure of the chain will begin from the remote node to the nearer node. If a node expires, the chain is rebuilt in the similar method to avoid the lifeless node.

Overall, the “PEGASIS” protocol offerings two or more than two presentation in contrast with the “LEACH” protocol [31], [32]. Though, the “PEGASIS” protocol reasons the dismissed data broadcast meanwhile one of the nodes on the sequence has been carefully chosen. Unlike “LEACH”, the conveying distance for most of the nodes is condensed in “PEGASIS”. Investigational consequences show that “PEGASIS” delivers enhancement by factor 2 compared to “LEACH” protocol for “50m x 50m network” and upgrading by factor 3 for “100m x 100m network”. The “PEGASIS” protocol, though, has a serious problem that is the terminated broadcasting of the data. The reason of this difficulty is that there is no thought of the BS’s location for the energy of nodes when one of nodes is nominated as head of node.

TEEN “Threshold sensitive Energy Efficient sensor Network protocol”:

Manjeshwar et al explains about “TEEN” as “The TEEN is a hierarchical protocol designed for the conditions like sudden changes in the sensed attributes such as temperature [11].” indeed, the responsiveness is important for all those situations, where the time critical applications are required, which mostly happened in the network of responsive node.

In this structure, the closer nodes form the clusters, and this procedure goes on the 2nd level until the sink is grasped. In this arrangement, the cluster-head broadcasts to its followers the *“Hard Threshold (HT)” and the “Soft Threshold (ST)”.* The “HT” is a threshold charge for the detected feature. It is the complete value of the feature beyond which, the node identifying this value must shift to its receiver and explain to its C.H. The “ST” is a minor alteration in the value of the identified feature which activates the node to shift on its receiver and communicate. The nodes identify their surroundings constantly. Firstly a parameter from the feature set access to “HT”, the node shifts on its receiver and directs the detected data. The identified value is deposited in an inner variable of the node, called the “sensed value (SV)”.

The key benefit of “TEEN” is that it performs sound in the circumstances like unexpected variations in the identified characteristics like temperature. On the other side, in big area networks and when the number of covers in the pyramid is small, “TEEN” inclines to consume a lot of energy, because of long remoteness broadcasts. Furthermore, when the number of covers rises, the broadcasts converts into shorter and overhead in the system stage as well as the process of the system exist.

APTEEN “Adaptive Threshold sensitive Energy Efficient sensor Network”:

The “APTEEN” is an expansion of “TEEN” and goals at both taking episodic data gatherings and replying to time critical events [12]. As soon as the BS formulates the clusters, the C.H transmits the features, the values of threshold and schedule of transmission to all nodes. After that, the C.H performs data accumulation, which has as a consequence to preserve energy. The core benefit of “APTEEN”, contrasted to “TEEN”, is that nodes use less energy. However, the foremost disadvantages of APTEEN are the complication and that it results in lengthier deferment times.

VGA “Virtual Grid Architecture Routing”:

VGA associates the “data combination and in-network processing” to get energy efficient system and expansion of network lifetime [13]. This whole scheme can be distributed into two phases, first is “clustering” and the other is “routing of aggregated data”. In the first phase, sensors are organized in a fixed topology because many applications require stationary sensors. Inside each cluster there is a CH, recognized as “local aggregator (LA)”, which performs the aggregation. A subdivision of this LA is designated to perform “global or in-cluster aggregation” and its associates are named as “master aggregator (MA)”. In the second phase, some heuristic are suggested which may provide effective, modest, efficient and an optimal solution. The core benefit of this protocol is that it can achieve energy efficiency and can expand the network lifetime, but the problem of optimal selection of LAs as MAs is a solid problem.

EESAA “Energy Efficient Sleep Awake Aware”:

The goal of EESAA is to minimize the energy consumption by using the concept of pairing. Sensor nodes of same application and which are at the minimum distance between them will form a pair for data sensing and communication. This protocol will also use the Cluster Heads selection technique, by selecting CHs on basis of the remaining energy of the nodes. Information from the sensor nodes is forwarded to the cluster heads (CHs) and these CHs are responsible to transmit this information to the base station which is placed far away from the field.

According to this scheme [2], the nodes switch between “Sleep” and “Awake” modes during a particular communication Interval. Firstly node in a pair, switch into Awake mode also called “Active-mode”. This happens if its distance from the sink is less than its coupled node. Node which is in “Active-mode” will gather data from surroundings and transmits it to the CHs. During this time period transceiver of the coupled node will remain “off” and switches into “Sleep-mode”. In the next step, nodes in “Active-mode” will switch into “Sleep-mode” and “Sleep-mode” nodes switches into “active-mode”. By this process the consumption of energy can be minimized because nodes which are in “Sleep-modes” save their energy by not interacting with the CHs. “Unpaired nodes” remain in “Active-mode” for each round till their energy resources died. This method lessons the energy consumption but is still not up to the mark for the upcoming network requirements. Another thing is that there can be large number of isolated nodes in the cluster which are left out in the coupling process, remain active for whole network life time, hence consuming considerable amount of energy.

Table 1. shows the summary of the comparison of hierarchical routing schemes.

TABLE I. HIERARCHICAL ROUTING SCHEMES COMPARISON (redrawn from [5])

Scheme	Advantages	Drawbacks	Scalability	Mobility	Route Metric	Periodic Message Type	Robust
LEACH	Low energy, ad-hoc, distributed protocol	It is not applicable to networks deployed in large regions and the dynamic clustering brings extra overhead	Good	Fixed BS	Shortest Path	None	Good
LEACH-C	The energy for data transmission is less than LEACH	Overhead	Good	Fixed BS	The best route	None	Good
PEGASIS	The transmitting distance for most of the node is reduced	There is no consideration of the base station's location about the energy of nodes when one of the nodes is selected as the head node	Good	Fixed BS	Greed route selection	None	Good
TEEN	It works well in the conditions like sudden changes in the sensed attributes such as temperature	A lot of energy consumption and overhead in case of large network	Good	Fixed BS	The best route	None	Limited
APTEEN	Low energy consumption	Long delay	Good	Fixed BS	The best route	IMEP Control	Good
VGA	It may achieve energy efficiency and maximization of network lifetime	The problem of optimal selection of local aggregators as master aggregators is NP-hard problem	Good	No	Greed route selection	None	Good

VI. CONCLUSION

WSNs have greatly prolonged playing a key role for the data efficient selection and delivery. The energy efficiency is a very most important issue for the networks particularly for WSNs which are described by "limited battery capabilities". Due to complexity in WSNs operations, what is required is the use of energy-efficient routing techniques and protocols, which will assure the network connectivity and routing of information with less required energy.

In this paper, our focus was on the energy efficient hierarchical protocols that have been developed for WSNs. If we talk about a large network, the flat protocols become "infeasible" because of link and the processing overhead. This is a problem and the hierarchical protocols try to solve it and as a result produce scalable, efficient and effective solutions. They split the network into "clusters "to proficiently maintain the energy consumption of sensor nodes and also perform "data aggregation and fusion" to lessen the number of transmitted messages to the sink. The clusters are arranged based on the energy backup of sensors and sensor's nearness to the CH. Thus, we can conclude that the hierarchical protocols are appropriate for sensor networks with the heavy load and wide coverage area.

So in order to develop a scheme that will prolong the lifetime of the WSNs is needed to increase the energy consumption of the sensors with in the network.

Therefore, the application of the appropriate routing protocol will enhance the lifetime of the network and at the same time it will guarantee the network connectivity and effective and efficient data delivery.

ACKNOWLEDGMENT

The authors are thankful to all.

REFERENCES

[1] RidhaSouaand Pascale Minet, " A Survey on Energy Efficient Techniques in Wireless Sensor Networks,"*IEEE Technical Program* at IFIP WMNC' 2011.

[2] T. N.Qureshi, T. Shah and N. Javaid. EESAA: Energy Efficient Sleep Awake Aware Intelligent Sensor Network Routing Protocol. *In Proceedings of 15th International Multi Topic Conference (INMIC)*, Islamabad, PK (13th to 15th December 2012).

[3] G. Anastasi, M. Conti, M. Francesco, A. Passarella, " Energy Conservation in Wireless Sensor Networks: A Survey," *Ad Hoc Networks*, 2009, Vol. 7, Issue 3, pp.537-568.

[4] I. F. Akyildiz, W. Su, Y. Sankarasubramaniam and E. Cayirci, "Wireless Sensor Networks: A survey," *Computer Networks*, Volume 38, N. 4, March 2002.

[5] Nikolaos A. Pantazis, Stefanos A. Nikolidakis and Dimitrios D. Vergados, "Energy-Efficient Routing Protocols in Wireless Sensor Networks: A Survey," *IEEE Communications Surveys & Tutorial*, vol 3, pp. 1-41, 2012.

[6] Nikolaos A. Pantazis, Dimitrios D. Vergados, "A survey on power control issues in wireless sensor networks," *IEEE Communications Surveys and Tutorials* 9(1-4): 86-107 (2007).

[7] *IEEE Pervasive Computing*, "Energy Harvesting and Conservation", Vol. 4, Issue 1, Jan-Mar, 2005.

[8] W. Heinzelman, A. Chandrakasan, and H. Balakrishnan, " Energy-efficient routing protocols for wireless microsensor networks," *In Proceedings of 33rd Hawaii International Conference on SystemSciences (HICSS)*, HI, USA, 2000, Vol. 8, pp. 110.

[9] X. H. Wu, S. Wang, "Performance comparison of LEACH and LEACH-C protocols by NS2," *In Proceedings of 9th International Symposium on Distributed Computing and Applications to Business, Engineering and Science*. Hong Kong, China, pp. 254-258, 2010

[10] S. Lindsey and C. S. Raghavendra.," PEGASIS: Power-efficient gathering in sensor information systems," *In Proceedings of the IEEE Aerospace Conference*, USA, Montana, March 2002, Vol. 3, pp.1125-1130.

[11] A. Manjeshwar, D. Agrawal," TEEN: A routing protocol for Enhanced Efficiency in Wireless Sensor Networks," *In Proceedings of 15th International Parallel and Distributed Processing Symposium (IPDPS'01)* Workshops, USA, California, 2001, pp. 2009-2015.

[12] A. Manjeshwar, D. Agrawal," APTEEN: A Hybrid Protocol for Efficiency Routing and Comprehensive Information Retrieval in Wireless Sensor Networks," *In proceedings of International Parallel and Distributed Processing Symposium,* Florida, 2002, pp.195-202.

[13] J. N Al-Karaki, R. Mustafa, A. Kamal, " Data Aggregation in Wireless Sensor Networks Exact and Approximate Algorithms," *In proceedings of IEEE Workshop High Performance Switching and Routing 2004*,Phoenox, AZ, 2004, pp241-245.

[14] M. J. Handy, M. Hasse, D. Timmermann, " Low Energy Adaptive Clustering Hierarchy with Deterministic Cluster-Head Selection," *In Proceedings of 4th International Workshop on Mobile and Wireless Communications Network*, USA, 2002, Vol.1, pp. 368-372.

[15] W. Heinzelman, A. Chandrakasan, and H. Balakrishnan, "An application Specific Protocol Architecture for wireless sensor networks," *IEEE trans. Wireless commun.*, 2002, Vol. 1, Issue 4, pp. 60-70.

[16] P. Minet , "Energy Efficient Routing", *in Ad Hoc and Sensor Wireless Networks: Architectures: Algorithms and Protocols*. Bentham Science 2009.

[17] I. Dietrich, F. Dressler, "On the lifetime of Wireless Sensor Networks", *ACM Transactions on Sensor Networks*, Vol.5, 2009.

[18] D. Tian, N. D. Georganas, "A coverage-preservingnode scheduling scheme for large wireless sensor networks", *In Proc. the 1st ACM International Workshop on Wireless Sensor Networks and Applications(WSNA)*,32-41, 2002.

[19] S. Soro, W. B. Heinzeiman, "Prolongingthe lifetime of wireless sensor networks via unequal clustering", *in Proc. the 19th IEEE Inetrnational Parallel and distributed Processing Symposium (IPDPS)*, 2005

[20] D. M. Blough, P. Santi, "Investigating upper bounds on network lifetime extension for cell-based energy conservation techniques in stationary ad hoc networks", *in Proc. the 8th ACM International Conference on Mobile Computing and Networking(mobiCom)*, 183-192.

[21] C. F. Chiasserini, I. Chlamtac, A. Nucci, "Energy efficientdesign of wireless ad hoc networks", *in Proc. the 2nd IFIP networking*. Vol. LNCS 2345, 367-386. 2002.

[22] S. Kumar, A. Arora, T. H. Lai. "On the lifetimeof always-on wireless sensornetwork applications", *in Proc. the IEEE International Conference on Mobile Ad-hoc and sensor systems (MASS),* Washington, November 2005.

[23] Al-Karaki, A. Kamal, "Routing Techniquesin Wireless Sensor networks: A Survey," *Security and Networks*, 2004, Vol. 11, Issue 6, pp. 6-28.

[24] K. Akkaya, M. Younis, "A Survey on Routing Protocols for Wireless Sensor Networks," *Ad Hoc Network, Elsevier*, 2005, Vol. 3, Issue 3, pp. 325-349.

[25] S. Guo, O. Yang, "Energy-Aware Multicasting in Wireless Ad hoc Networks: A Survey and Discussion," *Computer Communications, Elsevier,* 2007, Vol. 30, Issue 9, pp. 21292148.

[26] J. Yick, B. Mukherjee, D. Ghosal, "Wireless Sensor Network Survey," *Computer Networks*, 2008, Vol. 52, Issue 12, pp. 2292-2330.

[27] G. Anastasi, M. Conti, M. Francesco, A. Passarella, "Energy Conservation in Wireless Sensor Networks: A survey," *Ad Hoc Networks*, 2009,Vol. 7, Issue 3, pp. 537-568.

[28] R .V. Biradar, V. C.Patil, S. R. Sawant, R. R. Mudholkar, "Classifiacation and Comparison of Routing Protocols in Wireless Sensor Networks," *Special Issue on Ubiquitous Computing Security Systems*, 2009, Vol. 4, Issue 2, pp. 704-711.

[29] R. Yadav, S. Varma, N. Malaviya, "A Survey of MAC Protocols for Wireless Sensor Networks," *UbiCC Journal*, 2009, Vol. 4, Issue 3, pp. 827-833.

[30] S. Ehsan, B. Hamdaoui, "A Survey on Energy-Efficient Routing Techniques with QoS Assurances for Wireless Multimedia Sensor Networks," *IEEE Commun. Surveys Tuts*., 2011, Vol. 14, Issue 2, pp. 265-278.

[31] S. Jung, Y. Han, T. Chung, "The Concentric Clustering Scheme for Efficient Energy Consumption in the PEGASIS," *In Proc. 9th International Conference on Advanced Communication Technology, angwon-Do*, 2007, Vol. 1, pp. 260-265.

[32] L. Almazaydeh, E. Abdelfattah, M. Al-Bzoor, A. Al-Rahayfeh, "Performance Evaluation of Routing Protocols in Wireless Sensor Networks,"*Computer Science and Information Technology*, 2010, Vol. 2, Issue 2, pp. 64-73.

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