A Review on Energy Efficient Routing in Wireless Sensor Networks

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Abstract- There has been plenty of interest in building and deploying sensor networks. These networks have been composed of a high number of very simple nodes where the majority of them have to perform the function of a router also. Energy consumption of these nodes is significant factor as the power supply of the node is provided by limited batteries methodology, which limit the lifetime of the links in addition to whole networks. The energy treatment of network sensor node is serious issue for long lifespan of the network. As the sensor nodes are being acting like routers as well, the selection of routing algorithm would be a key role in the energy consumption control. In this review paper we have done study and the analysis of various research work related to Energy Efficient Routing in Wireless Sensor Networks in order to design an energy proficient path routing protocol for WSNs that is efficient in terms of the energy usage of the whole network such network would not get disconnected due to the the energy depletion of its nodes. Still there are numerous routing algorithms in this field are used for a protocol in real time network whereas the traffic is heavy and congested.

Key words- Energy, Efficient, Routing, Wireless Sensor Network, static, clustering, hole.

I. INTRODUCTION

The lifetime of a Wireless Sensor Network is depending on the residual energy level of its nodes. The case of most sensor networks it is impossible to recharge node's battery because of its unattended nature; hence effective utilization of the available energy sources of the node is vital. There are various routing schemes in sensor networks that utilize the available restricted resources at sensor nodes more efficient manner. These techniques are ordinarily attempting to discover the path with minimum energy for optimizing the energy usage at the nodes. Continually utilizing least energy paths may not be ideal from the network lifetime perspective and for long-term connectivity [8]. Network survivability is a metric that is more useful for improving the performance routing protocol. The protocol should make sure that, the connectivity is maintained as far as possible in a network, and the energy level of the whole network would be in an almost equal range. This is a situation which is opposed to the energy optimization protocols which will find the optimal paths between source and destination and then decrease the nodes energy along that path, which leaves the topology with wide difference in the energy health of the sensors, and leads to network, is disconnected into subnets. The power level of nodes in the network burns comparably, then the sensors located at the center of the network will be continuing for providing the connectivity for an extended duration of time, and the delay to get the network partitioned increases.

Wireless Sensor Network

A wireless sensor network consists of spatially distributed independent sensors those cooperatively monitoring the physical and environmental situations such as sound, temperature, vibration, motion, pressure or pollutants. The WSN is build of "nodes"- as of a few to several hundred and even thousands, where each and every node is linked to one (or several) sensors. A structure of a WSN is shown in given Figure 1.1.

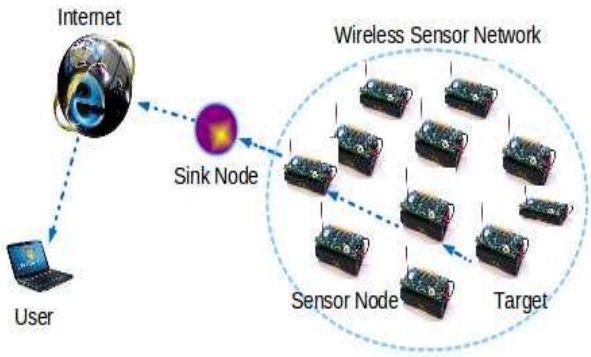

Figure 1.1: Wireless Sensor Network

In sensor networks are the environment is required to be remotely monitored, the data from the individual sensor nodes is sent to a central base station, through the end-user can access data.

Characteristics of WSNs include,

- Ease of use
- Ability to cope with node failures
- Communication failures
- Scalability to large scale deployment

- Power consumption for nodes that use batteries or Energy harvesting
- Ability to cooperate with harsh environmental conditions.

Routing in WSN

WSNs are intended for monitoring an environment. The main goal of a WSN is to collect data from a certain domain, forward it to the sink, where the application lies. Guaranteeing the direct communication between a sensor and the sink may drain the nodes' power very quickly, as of higher energy requirement in transferring messages. So, it is sometimes required that the nodes are collaborated to ensure communication of distant nodes with the sink. In this way, messages are propagated through intermediate nodes by establishing a route to the sink. Routing protocols for WSN are in charge of discovering and maintaining the routes in the network [1].

According to the participation style of sensor nodes, routing protocol in WSN could be classified into three categories. Direct Communication: In the case of direct communication, any node can be sent information directly to the Base Station (BS). Applying this routing technique in a very large network may drain the energy of sensor nodes rapidly. It's very small. Example: SPIN. Flat: In this type of protocols, if any node requests to transmit the data, firstly searches for a route to BS and after that transmits the data. This way, nodes around the BS may drain their energy quickly. Its scalability is average. Example: Rumor routing. Clustering: According to the clustering routing protocols, the whole area is divided into numbers of clusters. Each cluster has the cluster head (CH) and this cluster head can directly communicates with BS. Nodes are in a cluster send their data to their corresponding CHs. Example: TEEN.

Routing Protocols for WSN

There are some issues in the design of routing protocols for WSNs because of several constraints in the network. WSNs experience from the limitations of several network resources for example, energy, bandwidth, computation power and storage. The design challenges in sensor networks involve the following key aspects [2]:

Limited energy capacity:

Since the sensor nodes are battery powered having limited energy capacity, energy is a big challenge for the network designers in hostile environments. For example, in a battlefield, it is about impossible to access the sensors and recharge their batteries. Also, when energy of sensor reach to a certain threshold, it may become faulty and may not be able to function properly, which can have the major impact on the system performance. As a result, routing protocols designed for WSN shall be as energy efficient since it is possible to extend the lifetime of the sensors and therefore the network lifetime while guaranteeing decent overall performance. Sensor locations: Another challenge that is faced during the design of routing protocols is to manage the locations of the sensors. The majority of the protocols assume that the sensors either are equipped with GPS receivers or use some localization technique to learn about their positions.

Limited hardware resources

The processing and storage capacities of sensors are also limited as the energy capacity. Thus, they can only perform limited computational functionality. These constraints give rise to many challenges in network protocol design for WSN, which must consider not only the energy efficiency of sensor nodes, but also the processing power and storage capacities.

Massive and random node deployment:

Sensor node deployment in WSNs is application dependent and affects the performance of the routing protocol. Sensor nodes could be scattered randomly in a specified area or dropped massively over a remote or hostile region in most of the applications. When the resultant distribution of nodes is un-uniform, optimal clustering helps in connectivity and enabling energy efficient network operation.

Characteristics of Network and Dynamic environment

A sensor network generally operates in a dynamic and unreliable environment. The network topology, defined by the sensors and communication links between them, changes often because of sensor addition, deletion, damages, node failures or energy depletion. Furthermore, the sensor nodes are linked by a wireless medium, which is noisy, at risk for errors and time varying. Therefore, routing protocols should consider network topology dynamics to maintain particular application requirements in terms of coverage and connectivity.

Data Aggregation

Sensor nodes may generate significant redundant data. Similar packets from multiple sensors can be aggregated to reduce number of transmissions. Data aggregation methods are used to achieve energy efficiency and to optimize data transfer in the routing protocols.

Diverse application requirements

WSNs have a wide range of applications each having different requirements. No network protocol can meet all the requirements of every application. Hence, routing protocols should guarantee data delivery and its accuracy to provide the sink with the required knowledge about the physical and environmental condition on time.

Scalability

Routing protocols should be capable of scaling with the network size. Also, sensors need not necessarily have the same capabilities in terms of energy, processing and communication. Consequently, communication links between sensors may not be symmetric (i.e. a pair of sensors may not be able to have communication in both directions). This should be taken care of in the design of routing protocols.

II. SYSTEM MODULE

As stated earlier the algorithm designed is an attempt to have a routing protocol in Wireless Sensor Network which will burn the energy of the sensor nodes gracefully and hence increase the lifetime of the network. It is considering the scenario in which there are multiple source nodes which send their sensed data to the base station simultaneously, and therefore may having interference in the communication medium. The protocol has been designed to work in such an environment, and to route the data packet through the path that have interference and noise as minimum as possible. It is a destination initiated query driven algorithm. Destination node would initiate the process by sending the interest messages. The protocol mechanism in three phases.

Setup phase

Destination node initiates by broadcasting the interest packet (Route Discovery packet) to all it neighbors which in turn rebroadcast it to all their neighbors and so on. At the end of this phase multiple paths from source to destination are found out. It will find all the topologically possible paths from the source to destination. This is the phase when the routing table is created.

Data Communication phase

Source node will send the data to the next hop node which is selected from its routing table based on the defined path choosing factor. Each intermediate node will also select their relay nodes from their routing table based on this path choosing factor, as at the end of the setup phase the routing table is created at every node which contains the data about their own neighbors only.

Route Maintenance phase

This phase will work in a specified interval of time. At the beginning of a cycle the sink will send a route maintenance packet, which will update the routing table entries of the nodes in the network, and thus keeps the information up to date. At every node the next hop node is selected from its routing table based on the path choosing factor. The path choosing factor is a function of three things that are survivability factor of the path through the next hop node, SINR value of the link between itself and the next hop node, and the distance from the next hop to the destination.

$$Path\ Choosing\ Factor = \frac{SINR\ value\ X\ survivability\ factor}{Distance\ to\ sink}$$

The SINR value is the Signal-to-Interference-and-Noise-Ratio of the link between the current node and the next hop node. When the route discovery packet is received by a node it will calculate the signal strength of the received packet and calculate the SINR value for the link. And it will be stored in the routing table. Periodically it will be updated using the route maintenance packets. The survivability factor used is the modified one, the logarithmic path survivability factor.

$$f(a,c) = \frac{\log a}{\log c}$$

III. LITERATURE REVIEW

Ahmad, A., Latif, K. Javaid N. Khan [1] investigated on Cluster based routing method is most popular routing method in WSNs. Due to varying need of WSN application efficient energy use in routing protocols is at rest a potential field of research. In this research authors introduced new energy efficient cluster oriented routing method. This method is used to overcome the basic difficulty of coverage hole and energy hole. In their method they have controlled these problems by

introducing density controlled uniform distribution of nodes and fixed optimum number of Cluster Heads in each round. At the last authors had verified their methodology by simulation results in MATLAB.

Beiranvand, Z., Patooghy, A., Fazeli, M., [2] worked on large amount of energy on nodes of a WSN is consumed owing to the inner-network communications. An energy efficient routing algorithm is proposed which saves a important part of inner-network communications energy. The proposed routing method selects the sensor nodes with higher residual energy, extra neighbors, and lower distance from the Base Station as Cluster Head nodes. When, it manages sensor nodes suitably and constructs clusters this way to maximize WSN lifetime and reduce average energy dissipation per every sensor node. To approximation the proposed routing method, the proposed routing method has been compared with the previous proposed algorithms for example LEACH, DBS, and LEACH-C algorithms. Results of the simulation show that the proposed routing scheme has been improved the WSN act at least 65%, reduce the energy consumption of the WSN up to 62%, & improve the effectively delivered packet ratio at least 56% as compared to the previous routing scheme.

Lohan, P. and Chauhan, R., [3] presented the Geography-Informed Sleep Scheduling and Chaining Based Routing (GSSC) algorithm in wireless sensor network. As sensor nodes are energy constraint, the network lifetime by utilizing the energy of nodes very efficiently. GSSC saves energy by finding out equivalent nodes from routing perspective by using their geographical information the nodes, it sense almost same information and then turning off unnecessary nodes to remove data redundancy. To reduce the energy consumption of communication in network they use chaining based routing scheme to route the sensed data from active nodes to the base station. This chaining has been based data routing can reduce energy consumption of data transmission with the help of multi-hop routing concept. Our simulation results (using MATLAB) show that in comparison of very famous routing protocols like LEACH and PEGASIS, that algorithm has achieved significant increment in network lifetime.

Fareed, M.S., Javaid, N. and Ahmed [4] worked on the advent and development in the field of Wireless Sensor Networks in recent years has seen the growth of extremely small and low-cost sensors that possess sensing, the signal processing and the wireless communication capabilities. The sensors can be expended at a much lower cost and are capable of detecting conditions such as temperature, sound, security or any other system. Authors have compared six different protocols of different scenarios which are presenting their own schemes of energy minimizing, the clustering and route selection in order to have more effective communication. This work is to have an insight that which of the under consideration protocols suit well in which application and can be a guide-line for the design of a more robust and efficient protocol. MATLAB simulation results are performed.

Sathian, D., Baskaran, R. and Dhavachelvan [5] worked for Energy-constrained WSN has attained considerable research concentration now days and requires robust and energy efficient routing protocols for communication in fading environments to minimize the energy consumption. To moderate the fading effects in the wireless channels, MIMO method is utilized for energy efficient communication system and to route the data in WSN. The cluster head nodes can cooperate the transmit data cooperatively before selecting the cooperative sending and receiving groups in each cluster. The theory has been used to elect healthier cluster heads having enough residual energy and high faith level. The theory has been used to select the cooperative nodes for MIMO communication. The outcome show that the CH-C-TEEM routing algorithm provides more than 50% increase in residual energy as compared to TEEM.

Haneef, M., Zhou Wenxun, Zhongliang Deng, [6] proposed on limited energy resource is the major constraint associated with Wireless Sensor Network. As communication is the major cause of energy depletion in the network so designing of energy efficient routing algorithm is one of the key challenges that need to be address for extending life time of network. Author have taken the deployed redundant nodes in to account which cover major fraction of energy depletion in the network. They presents energy efficient routing algorithm based upon the frame work of LEACH. Lot of redundant data is available in wireless sensor network due to widely deployed nodes. That redundancy of deployed nodes can be used as an advantage for increasing network life time. To check our presented method author simulate it

using Matlab. Results show that MG-LEACH had outperformed LEACH on the basis of Network lifetime.

Seongsoo Jang, Ho-Yeon Kim and Nam-Uk Kim [7] worked on the development of the Wireless Sensor Network technology, ubiquitous technology comes to the fore as the core technology in the future. In the WSN, energy efficiency of the whole network is a key problem that has to be solved. Clustering is one of routing methods to improve energy efficiency. LEACH and LEACH-C are existing methdologies focused on optimizing energy efficiency of the network by applying clustering. Author suggest a new method, "Energy-Efficient Clustering scheme with Concentric Hierarchy (EECCH)," a centralized clustering scheme aimed at overcoming weaknesses of LEACH and LEACH-C both. By drawing circles with the base station as its center, the base point separates network nodes into some levels. The clusters have different numbers of its member nodes to eliminate inequality in energy dissipation through this process; it becomes possible to improve energy efficiency. By using MATLAB,

Saravanakumar, R., Susila and S.G., Raja, J.,[8] have donr research work on WSN. It consisting of a huge number of sensors is efficient for gathering the data in a selection of environments. Such as the sensor operates on battery of limited the power, it is big challenging aim to design an energy efficient routing protocol, that can minimize the delay while offering high-energy efficiency and long span of network lifetime. Author analyzes the basic distributed clustering routing protocol Low Energy Adaptive Clustering Hierarchy, also proposed a new routing method and data aggregation method in which the sensor nodes form the cluster and the cluster-head elected based on the residual energy of the individual node calculation without re-clustering and the node scheduling scheme is adopted in each cluster of the WSN. Output using MATLAB shows that the proposed routing protocol significantly reduces energy consumption and increase the total lifetime of the wireless sensor network compared to the LEACH protocol.

IV. PROBLEM FORMULATION

Task is to study and compare various routing algorithms used in Wireless Sensor Networks, clubbed with some placement algorithms such that they can address the following problem: Given a remote rectangular field, the task is establish a sensor network, having its base station at centre, with some sensor node placement and following a certain routing protocol, such that it can monitor fixed or randomly generated targets and report the targets to the base station, consuming less power & maintenance and without compromising with the performance.

The objective of this project is to develop a new clustering algorithm for WSN, improving on the existing LEACH Algorithm and its variations to outperform:

- The network life time.
- Consumption of energy in the network.
- Number of data received at the BS.

V. CONCLUSIONS

In this review work we analyzed the sensors nodes in WSNs have got only limited sources of energy and computing. The main limitation of these networks is the amount of energy consumption. The lifetime of a Wireless Sensor Network depends on its node's energy level. In most of sensor networks there is no way to recharge node's battery because of its unattended nature; therefore efficient use of the available energy sources of the node is vital. The routing protocol must consider the link quality and the possible interference and the noise level of the link before selecting a next hop node for communication. Wireless Sensor Networks, which may be spread over a vast geographical area, have their applications in many fields. There is a need of approaches which can manage these WSNs in a better way possible.

REFERENCES

[1]. Ahmad, A.; Latif, K.; Javaid, N.; Khan, A.; Qasim, U., "Density controlled divide-and-rule scheme for energy efficient routing in Wireless Sensor Networks," *Electrical and Computer Engineering (CCECE), 2013 26th Annual IEEE Canadian Conference on* , vol., no., pp.1,4, 5-8 May 2013.

[2]. Beiranvand, Z.; Patooghy, A.; Fazeli, M., "I-LEACH: An efficient routing algorithm to improve performance & to reduce energy consumption in Wireless Sensor Networks," *Information and Knowledge Technology (IKT), 2013 5th Conference on* , vol., no., pp.13,18, 28-30 May 2013.

[3]. Lohan, P.; Chauhan, R., "Geography-informed sleep scheduled and chaining based energy efficient data routing in WSN," *Electrical, Electronics and Computer Science (SCEECS), 2012 IEEE Students' Conference on* , vol., no., pp.1,4, 1-2 March 2012.

[4]. Fareed, M.S.; Javaid, N.; Ahmed, S.; Rehman, S.; Qasim, U.; Khan, Z.A., "Analyzing Energy-Efficiency and Route-Selection of Multi-level Hierarchal Routing Protocols in WSNs," *Broadband, Wireless Computing, Communication and Applications (BWCCA), 2012 Seventh International Conference on* , vol., no., pp.626,631, 12-14 Nov. 2012

[5]. Sathian, D.; Baskaran, R.; Dhavachelvan, P., "Lifetime enhancement by Cluster Head Cooperative Trustworthy Energy Efficient MIMO routing algorithm based on game theory for WSN," *Computing Communication & Networking Technologies (ICCCNT), 2012 Third International Conference on* , vol., no., pp.1,5, 26-28 July 2012.

[6]. Haneef, M.; Zhou Wenxun; Zhongliang Deng, "MG-LEACH: Multi group based LEACH an energy efficient routing algorithm for Wireless Sensor Network," *Advanced Communication Technology (ICACT), 2012 14th International Conference on* , vol., no., pp.179,183, 19-22 Feb. 2012.

[7]. Seongsoo Jang; Ho-Yeon Kim; Nam-Uk Kim; Tai-Myoung Chung, "Energy-Efficient Clustering scheme with Concentric Hierarchy," *RF and Microwave Conference (RFM), 2011 IEEE International* , vol., no., pp.79,82, 12-14 Dec. 2011.

[8]. Saravanakumar, R.; Susila, S.G.; Raja, J., "An energy efficient cluster based node scheduling protocol for wireless sensor networks," *Computational Intelligence and Computing Research (ICCIC), 2010 IEEE International Conference on* , vol., no., pp.1,5, 28-29 Dec. 2010.

[9]. Saravanakumar, R.; Susila, S.G.; Raja, J., "An energy efficient cluster based node scheduling protocol for Wireless sensor networks," *Solid-State and Integrated Circuit Technology (ICSICT), 2010 10th IEEE International Conference on* , vol., no., pp.2053,2057, 1-4 Nov. 2010.

[10]. Awwad, S.A.B.; Ng, C.K.; Noordin, N.K.; Rasid, M.F.A., "Cluster Based Routing protocol for Mobile Nodes in Wireless Sensor Network," *Collaborative Technologies and Systems, 2009. CTS '09. International Symposium on* , vol., no., pp.233,241, 18-22 May 2009.

[11]. Muhamad, W.N.W.; Naim, N.F.; Hussin, N.; Wahab, N.; Aziz, N.A.; Sarnin, S.S.; Mohamad, R., "Maximizing Network Lifetime with Energy Efficient Routing Protocol for Wireless Sensor Networks," *MEMS, NANO, and Smart Systems (ICMENS), 2009 Fifth International Conference on* , vol., no., pp.225,228, 28-30 Dec. 2009.

[12]. Dargie, Waltenegus, and Christian Poellabauer. Fundamentals of wireless sensor networks: theory and practice. John Wiley & Sons, 2010.

[13]. Shah, R. C., & Rabaey, J. M. (2002, March). Energy aware routing for low energy ad hoc sensor networks. In Wireless Communications and Networking Conference, 2002. WCNC2002. 2002 IEEE (Vol. 1, pp. 350-355). IEEE.

[14]. Mahgoub, Imad, and Mohammad Ilyas. Sensor network protocols. CRC press, 2006.

[15]. Singh, Suresh, Mike Woo, and Cauligi S. Raghavendra. ”Power-aware routing in mobile ad hoc networks.” Proceedings of the 4th annual ACM/IEEE international conference on Mobile computing and networking. ACM, 1998.

[16]. Draves, Richard, Jitendra Padhye, and Brian Zill. ”Routing in multi-radio, multi-hop wireless mesh networks.” Proceedings of the 10th annual international conference on Mobile computing and networking. ACM, 2004.

[17]. Heinzelman, Wendi Rabiner, Joanna Kulik, and Hari Balakrishnan. ”Adaptive protocols for information dissemination in wireless sensor networks.” Proceedings of the 5th annual ACM/IEEE international conference on Mobile computing and networking. ACM, 1999.

[18]. Kulik, Joanna, Wendi Heinzelman, and Hari Balakrishnan. ”Negotiation-based protocols for disseminating information in wireless sensor networks.” Wireless networks 8.2/3 (2002): 169-185.

[19]. Intanagonwiwat, Chalermek, Ramesh Govindan, and Deborah Estrin. ”Directed diffusion: a scalable and robust communication paradigm for sensor networks.” Proceedings of the 6th annual international conference on Mobile computing and networking. ACM, 2000.

[20]. Heinzelman, Wendi B., Anantha P. Chandrakasan, and Hari Balakrishnan. ”An application-specific protocol architecture for wireless microsensor networks.” Wireless Communications, IEEE Transactions on 1.4 (2002): 660-670.

[21]. Perkins, Charles E., and Pravin Bhagwat. ”Highly dynamic destination-sequenced distance-vector routing (DSDV) for mobile computers.” ACM SIGCOMM Computer Communication Review. Vol. 24. No. 4. ACM, 1994.

[22]. Perkins, Charles E., and Elizabeth M. Royer. ”Ad-hoc on-demand distance vector routing.” Mobile Computing Systems and Applications, 1999. Proceedings. WMCSA’99. Second IEEE Workshop on. IEEE, 1999.

[23]. Johnson, David B., and David A. Maltz. ”Dynamic source routing in ad hoc wireless networks.” Mobile computing. Springer US, 1996. 153-181.

[24]. Chen, Tseng-Yi, et al. ”ENERGY EFFICIENT GEOGRAPHIC ROUTING ALGORITHMS IN WIRELESS SENSOR NETWORK.” Journal of Interconnection Networks 14.01 (2013).

[25]. *OMNet++ version 4.3 User manual*, Andrs Varga and OpenSim Ltd., 2011