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Review Of Energy Efficient Routing Protocols In Wireless Sensor Networks

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***Abstract*— Wireless Sensor Network (WSN) refers to a class of spatially distributed and dedicated sensors for monitoring and recording the physical conditions of the surroundings and organizing the collected information at a central location. In several WSN applications, the device nodes are battery driven and need to recharge frequently. The energy consumption in WSNA depends on device nodes, design and Communication Protocols used. Energy efficient routing is one of the foremost effective to save energy in WSNs. Energy potency first and foremost issue coming up with a routing protocol. AN energy economical routing protocol is required to confirm network performance by prolonging network lifespan. Variety of efficient energy routing protocols were implemented. This paper deals with various methods utilized for efficient energy consumption in WSN.**

***Index Terms*— WSN, energy efficiency, routing protocol and network lifetime.**

I. INTRODUCTION

Wireless sensor networks are equipped with autonomous sensor nodes with a major motive to sense the environmental and physical conditions and route to the master sensor node that is base station that has uninterrupted power supply and is generally fixed. Energy is a limited resource in wireless sensor networks. In fact, the reduction of power consumption is crucial to increase the lifetime of low power sensor networks. As most of the energy consumption is originated by sensing, data processing and communication, these operations are the basis for identifying and exploiting energy saving potentials. The relation between energy consumption and communication range [1] in WSNs is $E = kd^n$, where E is the energy consumption, d is the communication range, and $2<n<4$, k is a constant. From the formula, we see that the longer the range, energy consumption is more. The major limitation is limited buffer size, limited energy supply, limited computing power, and limited bandwidth. So researchers are all involved in designing the energy efficient routing protocols or doing amendments in existing energy saving protocols for the energy conservation of sensor nodes. Several energy conservation approaches have been proposed for WSN. In addition, the sensor network should have a lifetime long enough to fulfill the application requirements. But not only it is important to manage existing resources correctly in order to avoid wasting them and reserve some of them for critical situations, but also regenerating or harvesting consumed energy as much as possible, to make network live longer. The routing protocols are used to find a path from source to target destination. Depending on the network structure, routing in the wireless sensor networks can be divided into three types: flat routing,

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location-based routing and hierarchical routing. So an energy efficient routing protocol is required to make sensor nodes live longer. This paper is organized as follows: Section II describes on routing factors in WSN design. Section III exhibits on different routing techniques. Section IV on review of related papers in WSN. Section V is on comparison of protocols. And finally conclude the paper in section VI.

II. ROUTING FACTORS IN WSN DESIGN

The design of routing protocols in WSN is influenced by many challenging factors. To achieve effective communication in WSNs these parameters should be taken care properly. Some of these parameters are discussed as below [2][3].

A. Energy consumption

Sensor nodes can use their limited supply of energy performing computations and transmitting information in a wireless environment. As such, energy conserving forms of communication and computation is essential. Sensor node lifetime shows a strong dependence on the battery lifetime.

B. Node deployment

Performance of the routing protocols depends on the node deployment. It may be in deterministic or random fashion. In deterministic method, sensor nodes are placed manually and data is passed through predetermined paths. In random method, nodes are scattered randomly in an adhoc manner. Now day's sensor nodes are equipped with Global Positioning System.

C. Fault tolerance

In the event of node failure, routing protocol must provide new paths. So that data transmission or reception process should not get affected. Failures may be due to physical damage, environmental disturbance or lack of power.

C. Scalability

In most of the sensing applications hundreds or thousands of sensor nodes are deployed. Routing protocols should be able to work with these huge numbers of nodes. Sometimes nodes may go to sleep mode and awake on demand. So nodes should be extremely scalable.

D. Data aggregation

Sensor nodes may provide redundant data. Aggregation technique is used to eliminate redundant data. While aggregating data similar kind of packets are discarded and only the aggregated data is transmitted. This is also one of the energy efficient techniques in routing protocols.

E. Quality of service

Sensor networks may have different Quality of Services (QOS) based on their application like latency, packet loss. Hence routing protocol must take care of their QOS requirements for particular application. By considering all these factors in WSN, routing techniques are developed and discussed in the next section.

III. ROUTING TECHNIQUES

The routing protocols are used to find a path from source to target destination. Depending on the network structure, routing in the wireless sensor networks can be divided into three types: I) Flat based routing, II) Location-based routing and III) Hierarchical routing.
Depending on the protocol operation, routing protocols are classified as Multipath routing, Query based routing, negotiation based routing and QOS based routing. Fig1 shows the classification of routing techniques.

A. Flat based routing (Flooding)

In flooding all sensor nodes have equal functionality in flat based routing i.e. all nodes collaboratively perform sensing task. Since large number of sensor nodes, assigning global identifier is not feasible to each node. This leds to data centric routing. Where BS sends queries to collect data from selected sensors in certain region. SPIN[4] and directed diffusion[5] are the examples of this routing.

B. Hierarchical based routing (clustering)

In the network, if sensor nodes play different roles that type of technique is known as hierarchical based technique. Hierarchical routing is mainly used for scalability and energy efficient communication. Here low energy nodes can be used to sense the data and high energy nodes are used for processing and sending the data.

C. Location based routing (Geographic)

In the network, if sensor node positions are exploited to route data is known as location based technique. Based on the signal strength distance between neighboring nodes is calculated. To save energy many nodes goes to sleep state.

D. Multipath routing

To enhance network performance multipath routing is used instead of single path. Due to this in any condition if main path fails, there exists always an alternate path.

E. Query based routing

In this routing, the destination nodes propagate a query for data, from a node through the network and a node having this data sends the data which matches the query back to the node, which initiates the query.

F. Negotiation based routing

Through negotiation based method redundant data's are eliminated or suppressed. Based on the resources available communication decisions takes place.

G. QOS based routing

Sensor network has to satisfy some quality of services while sending data to base station. Services are bandwidth, delay, packet loss, energy etc.

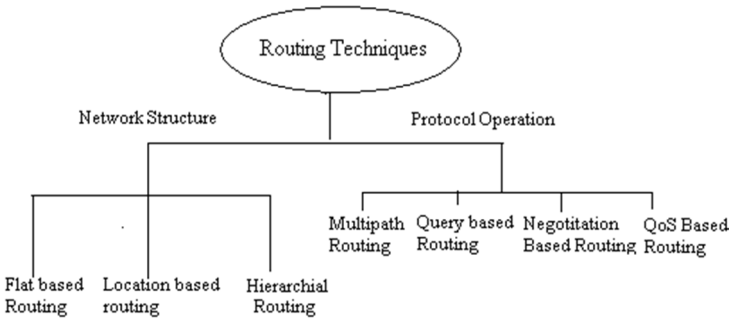

Fig1: Routing Techniques

IV. RELATED WORK

Enormous papers are published based on the routing protocols. These protocols are based on network structure or based on protocol operation or application needed. An approach is done to list some of these papers.

Low energy adaptive clustering hierarchy (LEACH) [6] is one of the most popular algorithms. LEACH forms the clusters based on the received signal strength. LEACH uses local cluster heads as routers to the sink. The transmission of data is done only through these cluster heads rather than all the sensor nodes in the network. This will save energy as only cluster heads are responsible for transmission of data towards sink. These cluster heads change randomly over time depending on energy dissipation of the sensor nodes. This decision is made by the node choosing a random number between 0 and 1. The node becomes a CH for the current rotation, if the number is less than the threshold value. Data from cluster nodes to BS achieves through CH.

Time division multiple access (TDMA) scheduling scheme has balanced energy and end-to-end delay of wireless sensor networks. This balance achieves with appropriate scheduling of the wake-up intervals. From sensors to gateway it takes one sleep interval for data transmission. TDMA scheduling algorithm [7]

scheduling reduces sleep mode delay in WSN. TDMA algorithm initially builds the transmission schedule. Transmission schedule is flooded back to the sensor nodes, allowing them to know when they can transmit or receive a packet. Energy-saving phase determines sleep and wake-up periods using initial transmission schedule.

Memetic algorithm (MA) [8] is a dynamic optimal design algorithm. Memetic algorithm optimized the design based on the battery level threshold values for each operating modes of sensors. The MA approach is materialized through local search and threshold update schemes. Local search initialize the threshold values of battery levels for each three possible operating modes are CH, Higher Sensor Range (HSR), and Lower Sensor Range (LSR) defined. If battery level is below its threshold, then operating mode is changed to lower mode until its corresponding threshold value becomes lower.

Geodesic sensing element Clustering (GESC) [9] could be a Distributed bunch algorithm program and designed for multi-hop networks. Clustering creates the stratified base structure. Network management technique uses the residual energy for choosing cluster head. The clustering protocol is split into 2 major procedures: the cluster formation procedure (CFP) and also the network operation procedure (NOP). The period of the cluster formation procedure is the interval required to form the network, whereas the period of the network operation procedure is the time interval between 2 subsequent intervals. The clustering protocol is split into rounds and at the start of every round CFP is triggered. The NOP follows the CFP once information transferred from the nodes to cluster heads and forward through multi-hop methods to the base sink.

Geographical adaptive Fidelity [10] is an energy-aware routing protocol primarily planned for MANETs; however it may be used for WSNs. It favors energy conservation. The design of GAF is based on an energy model that considers energy consumption attributable to the reception and transmission of packets and idle (or listening) time once the radio of a sensing element is on, to observe the presence of incoming packets. GAF is predicated on mechanism of turning off inessential sensors whereas keeping a relentless level of routing fidelity.

Reliable and Energy Balancing Multi-Path Routing algorithm [11] for Wireless sensor Networks. The REMP protocol guarantees the mentioned quality of service parameters in wireless sensor networks and balances the energy consumption altogether detector nodes. By the way of simulations, the authors have evaluated and compared the performance of defined routing protocols with the MCMP (Multi-Constraint Multi-Path) and EQSR (Energy efficient and QoS aware multipath routing protocol) routing protocol.

Receiver-driven medium access Control (RMAC) [12] could be a form of TDMA primarily based programming theme. In contrast to alternative MAC protocol, every node in its time interval can receive message from alternative nodes. To avoid co-occurring message transmission from multiple nodes to the receiver node, every receiver node can have a sender node on its scheduled period. In comparison with alternative Receiver MAC protocol, it is having time stealing mechanism. If the sender node is not transmission any message on that time interval of receiver node, then the assigned time interval are derived from nearby sender node to transmit its message to the receiver node.

Multi Layer-MAC [13] could be a distributed contention-based and self organizing MAC protocol, wherever nodes discover their neighbours based their radio radiation level. ML-MAC divides detector nodes into layers. Layers are arbitrarily chosen by nodes and its period of every layer is split into range of frames. Every frame decides its listen and sleep periods. The listen periods of nodes in several layers are non-overlapping. A node within the ML-MAC protocol wakes up solely at its assigned layer's listen duration. ML-MAC reduces the energy consumption than alternative protocols by reducing the rise time of every node through layer architecture.

Adaptive service provisioning mechanism [14] planned the adaptive service provisioning to increase energy potency. The flexibleness of wireless sensor networks is achieved through novel service binding ways that mechanically adapt application behavior. Adaptation mechanism is split into 3 parts: energy-aware SELECTION, shared service invocations, and adapting the configuration changes. Choosing the PROVIDER is to decide on the one that end in the applying having the tiniest energy footprint. Service sharing permits multiple service execution requests that can be combined into one execution of the service.

Optimal wake-up frequency assignment algorithm (OWFA) [15] exhibits both centralized and distributed mechanism. OWFA assigns optimum wakeup frequency to all or any nodes within the information gathering tree. OWFA has 3 procedures as: Alpha procedure, Combine-Node procedure and Assign frequency procedure. Alpha calculates optimum wake-up frequency by summing the overhead energy values and information transmission energy values of all child nodes. Combine-Node procedure recursively calculates the combined energy consumption coefficient of the base node. The base node assigns the wake-up frequency of every node.

Energy Efficient cluster node (EECL) data transmission [16] is distributed over the sensors that forms optimum clusters. The cluster has been created and therefore the data transmission is mounted with TDMA technique. Sensors nodes need to send the info throughout its allocation transmission time to the CH. when allocating transmission time for every node, the radio of CH node is communicate off. once wake-up time CH receives information from remaining nodes and therefore the information has been aggregated The info has sent through energy Efficient CH to Base station.

Network coding -based cooperative ARQ (NCCARQ MAC) protocol [17] could be a network coding technique. NCCARQ correlates the transmissions between a group of relay nodes that supports a bidirectional communication among pair of nodes. NCCARQ-MAC permits wireless workstations to request cooperation of neighboring nodes for proper reception of a data packet. It permits the helper nodes to perform network coding techniques to the packets to be transmitted before relaying the packets. The relay store, a duplicate of any captured information packet till it is acknowledged by the supposed destination. The error mechanism, like Cyclic Redundancy Code is applied to perform error management for receiving messages.

Cluster based routing protocol (EADC) [18] could be a cluster-based routing protocol. EADC calculates average residual energy and waiting time of every node. If a node has not receive any header message from remaining nodes within the waiting time, then it elects as a CH. the remaining nodes are joined as members to CH. CH broadcast the schedule to its cluster members. Throughout its schedule, nodes transmit the info to CH. If the DISTANCE between the CH to BS is a less than the calculated threshold, then it will have BS as next hop. Otherwise, it will forward to next CH node having higher residual energy.

Improved LEACH protocol (WLEACH) [19] is Wise Low Energy adaptive clustering Hierarchy by 3 improved aspects: the primary side is adding considering of energy ,the second side is adding multi-jump routing between nodes, and therefore the third side is adding dormancy of cluster head node. Considering the primary aspect, known that LEACH protocol limits the node times to become the cluster head, which might avoid node's death based on cluster-head node' a lot of energy-using, they additionally become low-energy and straightforward to die. So as to unravel this drawback, it is necessary to limit the energy a node become cluster-head. Currently there has been some theory regarding energy threshold, like initial node's energy, the average energy of whole cluster and therefore the average energy of whole network. LEACH Centralized with Chain protocol could be a hierarchical protocol [20]. Where every node makes autonomous selections that end in all the nodes being placed into clusters, this protocol offers no guarantee concerning the location and/or number of cluster-head nodes. Since the clusters are adaptive, getting a poor clustering set-up throughout a given round will not greatly have an effect on overall performance of LEACH. However, employing a central management rule to make the clusters could produce better clusters by dispersing the cluster-head nodes throughout the network. Then a chain routing between cluster-heads is established to scale back the quantity of nodes that communicate with the base station. Any improvement in energy cost for information gathering are often achieved if one cluster-head transmits to base station and if every cluster-head transmits solely to local neighbor cluster heads within the information fusion phase.

Virtual Backbone and ERPMT Techniques [21] used to increase lifetime of network .In VBS methodology rather than making one backbone we have a tendency to making a multiple overlapped backbones to figure as an alternative. This could increase the life of WSN comparably. In ERPMT methodology we have a tendency to divide the node energy into 2 ratios; one for the device node originated information and therefore the alternative one is information relays from alternative sensors. The performance is evaluated by considering the QoS parameters like data rate, packet loss ratio, bandwidth and SNR value.

Big Bang huge Crunch (BBBC) primarily based metaheuristic algorithm [22] is proposed for the choice of Cluster Head in some way in order that its energy is employed uniformly with delayed disintegration of

network. The Big Bang and massive Crunch theory is introduced by Erol and Eksin, that relies upon the analogy of universe evolution wherever 2 section of evolution is painted by enlargement (Big Bang) & contraction (Big crunch). This algorithm incorporates a low computational time and high convergence speed. In fact, the Big Bang section dissipates energy and produces disorder and randomness. Within the huge Crunch section, randomly distributed particles are organized into associate order by way of a convergence operator "center of mass". The Big Bang–Big Crunch phases are followed as an alternative till randomness among the search house throughout the Big Bang becomes smaller and smaller and at last resulting in an answer.

K-Hop based algorithm [23] is proposed for formulate a huge clustering will effectively handle energy efficiency parameter. However in SENSOR networks some Sensor nodes could interrupt to alternative cluster range. This function is termed cluster overlapping problem. In ancient cluster algorithm each node can belong to just one cluster. However during this algorithm one node could belong to more than one cluster. The key plan of this algorithm is that it considers bidirection links. Thus this is often better option for a network that has vast range of device nodes.

PDORP-PEGASIS DSR (Dynamic supply Routing) optimized routing protocol [24], optimally utilizes proactive and reactive routing model. They need ascertained that additional energy is consumed by the nodes within the role of CH. thus the amount of cluster heads ought to be optimized. Another challenge is to receive the info from trust worthy devices in order that hidden or malicious nodes couldn't disrupt the route. The PDORP algorithm has decreased the communication distance between the nodes in order that less energy is consumed. once a node becomes additional aggressive at the time of information transfer, the opposite node is certain to receive a packet from it and in such some way it will cause harm to existing routes. The proposed solution creates a trust for the primary time in every round on the idea of the parameters allotted to the nodes. After each round, the trust list is updated and when an exact range of rounds, the trust wouldn't be checked to avoid time delays.

V. Comparision Of Few Routing Protocols

Table 1 compares the different energy efficient routing protocols with respect to their energy consumption. Based on the energy consumption routing protocols are used for different applications.

TABLE1: COMPARISON OF DIFFERENT ROUTING PROTOCOLS

SL No	Author	Year	Protocols	Energy Consumption
1	Heinzelman et.al	2000	Leach	High
2	Intanagonwiw at, C et al.	2000	Direct diffusion	Limited
3	A.Manjeshwar et.al	2001	Teen	High
4	J. Kulik et.al	2002	Spin	Limited
5	Lindsey et.al	2002	Pegasis	Maximum
6	O. Younis et.al	2004	Heed	Low
7	Sangho Yi	2007	Peach	Limited
8	A.Manjeshwar	2009	Apteen	High
9	Sinchan et.al	2010	Gaf	Limited
10	Laiali Almazaydeh	2012	Vga	Low
11	Dr.T.V.U kiran et.al	2013	Vberpmt	Low
12	Archana et.al	2014	Bbbc	Low
13	Manikandam.K et.al	2015	Koca	Low
14	Gurbinder S B et.al	2016	Pdorp	Low

VI. Conclusion

In this paper, we have reviewed many research papers based on different design issues in Wireless sensor networks. Here we mainly concentrate on energy efficient routing protocols in WSN. It is difficult to

compare them directly because each method is distinct with different underlying assumptions. But still energy efficient and network lifetime prolongation routing protocols are required.

REFERENCES

[1] Chao Wang, Hailing Wang et al, "The Studies on Energy Control of Protocols in Wireless Sensor Networks", IEEE Communication Magazine, 2006.

[2] W.HeinZelman, A.Chandrakasan and H.Balakrishnan, "Energy Efficient Communication Protocol for Wireless Microsensor Networks," Proceedings of the 33rd Hawaii International Conference on System Sciences (HICSS'00) January 2000.

[3] Chong C-Y,Kumar S P,Sensor networks: evolution, opportunities and challenges. Proceedings of the IEEE 2003; 91(8);1247-56.

[4] W.Heinzelman, J.Kulik and H.Balakrishnan, "Adaptive protocols for Information Dissementation in wireless sensor networks," Proc.5th ACM/IEEE Mobicom Conference (MObicom'99) , seattle, WA, August, 1999.

[5] C.Intanagonwiwat, R.Govindan,and D.Estrin, directed Diffussion: A Scalable and robust communication paradigm for sensor networks," Proceeedings of ACM Mobicom'00,Boston,MA,2000.

[6] W. Heinzelman, A. Chandrakasan and H. Blakrishnan, "Energy-efficient communication Protocols for Wireless Microsensor Networks." International Conference on System Science (HICSS -34), 2006.

[7] Nikola A. Pantazis Dimitrios J. Vargados, Dimitrios D. Vergados and Christos Douligeris. "Energy efficiency in wireless sensor networks using sleep mode TDMA scheduling. Ad Hoc Networks."2009.

[8] Konstantinos P. Ferentinos and Theodore A. Tsiligiridis. "A memetic algorithm for optimal dynamic design of wireless sensor networks", Computer communications. 33: 250-258.2010

[9] N. Dimokas, D. Katsaros and Y. Manolopoulos, "Energy-efficient distributed clustering wireless sensor network.", J. Parallel Distrib. Comput. 70: 371-383.2010

[10] Sinchan Roychowdhury, Chiranjib Patra, "Geographic Adaptive Fidelity and Geographic Energy Aware Routing in Ad Hoc Routing", IJCCT, Aug. 2010

[11] Ali Ghaffari, Nasrin Firuz and Hanieh Rahbari Bannaeian , "Reliable and Energy Balancing Multi-Path Routing Algorithm for Wireless Sensor Networks," World Applied Sciences Journal 15 (5): 737-744, 2011 ISSN 1818-4952.

[12] Wee LumTan, Wing Cheong Lau and Onching Yue, " Performance analysis of an adaptive, energy-efficient MAC protocol for wireless sensor network", J. Parallel Distrib. Comput. 72: 504-514.2011

[13] Manish Kumar Jha, Atul Kumar, Pandey, Dipankar Pal and Anand Mohan, " An energy-efficient multi-layer MAC (ML-MAC) protocol for wireless sensor networks", International Journal of Electronics and Communications. 65: 209-216. 2011

[14] N Chien - Lian Fok, Gruia- Catalin Roman and Chenyang Lu, " Adaptive Service Provisioning for enhanced energy-efficiency and flexibility in wireless sensor network", Science of computer programming,2011

[15] Ungiin Jang, Sunggu Lee and Sungoo Yoo, " Optimal wake-up scheduling of a data gathering trees for wireless sensor network", J. Parallel Distrib. Comput. 72: 536-546,2012

[16] T. Venu Madhav and N.V.S.N. Sarma, " Maximizing Network Lifetime through Varying Transmission Radii with Energy Efficient Cluster Routing Algorithm in Wireless Sensor Networks", International journal of Information and Electronics Engineering.(2),2012.

[17] Angelos Antonopoulos, Christos Verikoukis, Charalabos Skianis and Ozgur B. Akan, "Energy efficient network coding-based MAC for cooperative ARQ wireless networks. Ad Hoc Networks",2012.

[18] Jiguo Yu, Yingying Qi, Guanghui Wang and Xin Gu, "A Cluster-based routing protocol for wireless sensor networks with non uniform node distribution", International Journal of Electronics and Communications. 66: 53-61,2012.

[19] Chen Yueyun, Zhu Yue-long, An Jianwei,et al, "An Energy-saving Routing Protocol Based on LEACH", IEEE, 2012.

[20] Baiping Li, Xiaoqin Zhang et al, "Research and Improvement of LEACH Protocol for Wireless Sensor Network", IERI, 2012.

[21] Dr. T.V.U. Kiran Kumar, Ms. S. Arulselvi and S.Sudha Praba, "WSN Life Time maximization using Virtual Backbone and ERPMT Techniques", IJESRT, 2013.

[22] Archana and Sukhjinder kaur, "A New BBBC based LEACH Algorithm for Energy Efficient Routing in WSN ", IJECS, Volume 3 Issue 2, February 2014 Page No. 3914-3918.
[23] Manikandam.K, kanmani.P and Munnira sulthana.M "Energy Efficient Algorithms for Wireless Sensor Networks", IJARCCE, Volume 4,Issue 1,Jan 2015.
[24] Gurbinder Singh Brar,Shalli Rani,Vinay chopra,Rahul Malhothra,Houbing Song and Syed Hassan Ahmed, Energy efficient Direction based PDORP routing protocol for WSN",IEEE Access, June 7,2016.

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