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A Review on Energy Efficiency Protocols in WSNs

Bhawana Saini, Rajendra Aaseri
Computer Science Department, Lovely Professional University,
Punjab, India

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A wireless sensor network (WSN) is developing over miscellaneous areas to give new opportunities for the services as well as occasions for the networks. The advancement of micro electro-mechanical systems has made sensor networks a very fascinating area for research. The primary issue in sensor networks is energy optimization. Energyoptimization means how wisely we use energy. Energy efficiency programs are plotted tolower the use energy of members participating. Numerous approaches and algorithms havebeen proposed toeradicate the issue of energy optimisationThis paper explores the competing issues of energy consumptionefficiency in wireless sensor network..In this paper, we review the key coverageoptimization protocols and present open research issues related to energy efficient coverage.

Keywords— WSN, PEGASIS, Clustering, BS, CH, LEACH.

I. INTRODUCTION

1.1 Wireless Sensor Networks

Wireless Sensor Networks composed of numerous tiny electronic devices called nodes which gather the data from their environment nearby and then send the collected data to base station where further analysis and forecasting can be done. The analysed data is used to take managerial resolutions or business decisions. In multiple issues and numerous scenarios the sensor networks have become tool for data analysis. This has given the capability of remotely monitoring of a physical surrounding for a wide and distinct scenarios and different problem context. These tiny nodes are self-regulating which provide ability of distributed computing in the network. With distributing computing the network can be made flexible or ductile to adopt several methods for deployment, security enforcement, and routing and data dissemination.

Energy efficiency is an important aspect in WSN as nodes have a finite battery power. The various types of limitations make WSN and different protocols challenging and divergent. WSN has emerged as a completely different technology as compared to standard traditional internet architecture. WSN nodes are very tiny and occupy lower space and weight as compared to traditional networked devices. WSN easily scales to the order of thousands of nodes and requires minimal help from outside to build the network. The latest advancements in wireless have made the smaller and less expensive products which enhance communication speed significantly.

All nodes in WSNs have a battery with fixed power which makes energy conservation as basic need while creating architecture of WSN [30]. The objectives in the creation of WSNs have the capability of huge rate of data exchange among nodes in the network and base station and ability of minimizing the energy consumption. We need efficient routing protocols in WSNs to achieve these objectives. Therefore, several routing algorithms have been proposed [23].Cluster Based routing protocols composed of two layer architecture. One layer is responsible for section of cluster head and the other handles routing. A cluster head (CH) is one which is performs collection of data from rest nodes, gathering or pre-processing of data and then dispatching the processed data to the base station.

1.1.1 Data Aggregation in WSN

In a huge network with thousands of sensor nodes, the data coming from the individual node does not make perception when compared to the data aggregated from clusters of nodes. Here, the raw data from multiple nodes will be buffered or processed and aggregated in one node which acts as an aggregator. Data aggregation considerably lowers down the cost of transmission and as a result keeps the network available for a longer time period and provides optimal bandwidth usage.

1.2 Components and Characteristics

Wireless Sensor Networks made up of abundant nodes deployed on a wider area range. They have furnished with various sensors like optical, thermal or mechanical to monitor the properties of the physical environment, where they are located. There are three perspectives for understanding the components of WSN: hardware, software for making up a sensor, and the network that is collection of many sensor nodes.

1.2.1 WSN Hardware

A sensor node consists of beneath units:

A **Sensing Unit:** For collection of data from the surroundings.

A **Processing Unit:** Data is processed.

A **Communication Unit:** Data storage takes place.
A **Power Unit:** Used to perform the required tasks.
Below are some ways which are defined to utilize the energy in an efficient manner:
Deployment of sensor nodes
Energy Efficient Clustering
Energy Efficient Scheduling
Data Aggregation
Energy Efficient Routing Protocols

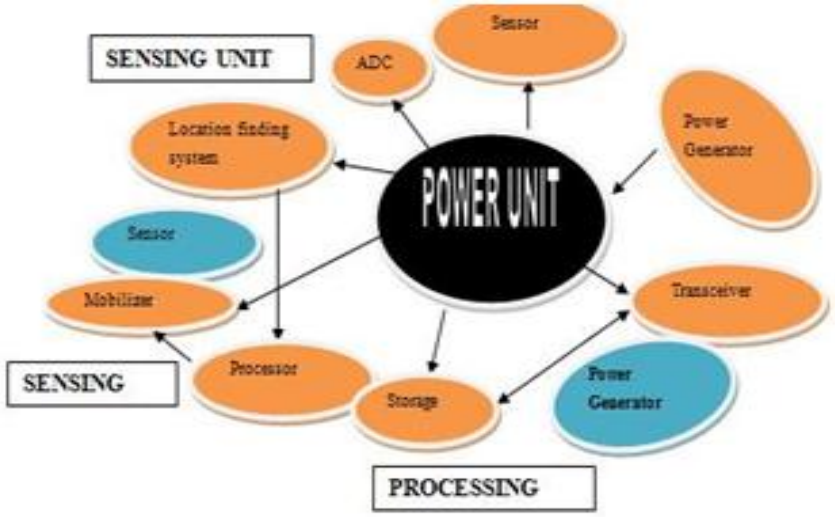

Fig.1 Architecture of WSN.

1.2.2 WSN Software

In WSNs among sensing, consumption and communication, the factor of communication consumes the maximum energy [30]. One way to decrease energy consumption due to communication is to impose an efficient medium-access control (MAC) protocol. The MAC protocol governs antenna activities and is responsible for reliable connections which can lead us to a successful and collision-free network. Energy efficiency, device management and efficient resource utilisation are three basic features that should be considered while designing MAC layer protocol [30]. There are many MAC protocols that have been developed but most of the current MAC designs for WSNs are classified as TDMA (Time Division Multiple Access) protocol [12].

1.3 Classification of Routing Protocols

Two broad categories of routing protocols can be defined as hierarchical and flat. Where equal roles are assigned to all members with each having same kind of functionality is known as Flat Routing while on contrast, in hierarchical routing nodes are assigned distinct roles [36] and formation of clusters occurred. Some of the major limitations and challenges facing the existing protocols are to satisfy the new WSNs requirement can be listed as the following:

1. **Limited Energy Resources:** With the mobile infrastructure, the finite battery powerneeds to be managed, thus energy aware protocols are highly required. Even if we work on lifespan of battery only still as long as the battery become empty the sensor node become dead.
2. **Lower Data Rates:** The major struggles are the limited data rates. The frequencythat is used effect on the data to be transmitted. This justifies that wired networks are faster than the wireless networks.
3. **Communication failures:** Error rate is high in wireless networks than their wiredequivalent. Electronic waves are used to send packets and these waves can be distracted by unexpected occurrence events of reflection, refraction, diffraction or scattering.
4. **Security issues:** Wireless networks are more attack prone. Many unwanted andexternal users can enter the networks for attacking the system.

Flat and Hierarchical Routing Protocols

Network routing protocols are directing routing mechanisms as well as maintaining the structural aspect of network in WSNs. There are three types of network structure: flat routing [10], hierarchical routing [8, 17] and location-based routing [5, 7 and 14]. However, in order to focus in our area of research, we discussed only two of them (flat and hierarchical routing protocols).

Flat Routing: Where equal roles are assigned to all members with each havingsame kind of functionality is known as Flat Routing. Here, it is possible to assign value as a global value to every member due to large size of network. So, queries are sent by base station to different part of the sensing field. This mechanism is called data centric routing [23]. SPIN (Sensor Protocols for Information via Negotiation) [3] and DD (Direct Diffusion) [18] can be two examples. In these protocols energy is conserved by omission of repetitive data.

*Cluster-Based or Hierarchical Routing***:** In this methodology, nodes play separate anddistinct roles while data transmission. While few nodes sense the target area on the other hand other nodes are responsible for processing and communication. In hierarchical routing one layer work on selection of cluster head while the second layer works on routing. The ultimate aim of all these protocols is designing and choosing cluster heads in such a way that the energy is utilised. Cluster based Routing is a feasible solution for minimising energy utilisation in WSNs. Within a cluster, management of member nodes and assignment of tasks to them is done by cluster head which result to reduction in redundant data transmission. Energy consumption highly lowered in this routing method since the total data messages at the base station is minimized by data aggregation which is performed by cluster head.

Table.1 Comparison between Hierarchical and Flat Routing.

Hierarchical routing	Flat routing
Reservation-based scheduling	Contention-based scheduling
Collisions avoided	Collision overhead present
Reduced duty cycle due to periodic sleeping	Variable duty cycle by controlling sleep time of nodes
Data aggregation by clusterhead	Node on multihop path aggregates incoming data from neighbours
Simple but non-optimal routing	Routing can be made optimal but with an added complexity.
Requires global and local synchronization	Links formed on the fly without synchronization
Overhead of cluster formation throughout the network	Routes formed only in regions that have data for transmission
Lower latency as multiple hops network formed by	Latency in waking up intermediate nodes cluster- heads always available and setting up the multipath
Energy dissipation is uniform Energy dissipation depends on traffic patterns	Energy dissipation cannot be controlled Energy dissipation adapts to traffic pattern
Fair channel allocation	Fairness not guaranteed

1.3.1 LEACH Protocol

Low Energy Adaptive Clustering Hierarchy (LEACH) presented by Wendi B. Heinzelman of MIT as a clustering-based protocol that utilizes random movements of local cluster base station (CH) to distribute the energy load evenly among the sensors in the network [3]. The LEACH works on the concept of incorporating data fusion to reduce the amount of information that must be transmitted to base station and on localized coordination to bring the features of scalability and robustness for networks.

The network's clustering is rearranged dynamically and periodically. LEACH takes all members, as they can communicate to a base station with transmission at high power. This introduces the strategy of cycles/rounds. LEACH protocol undergoes multiple rounds.

Every cycle/round can be completed as:

A. Cluster setup phase
B. Steady state phase

A. Cluster setup phase

Each node takes a self-decision either it should become a cluster head or not for current processing round. The node takes its decision done via selecting a random value between 0 and 1. The threshold is set as:

$$T(n) = p/\left(1 - p\left(r \bmod \left(\frac{1}{p}\right)\right)\right) \text{ if n belongs to G}$$

Where,
p is the node's probability taken as a cluster-head
r is the rounds that already occurred

G is the group of nodes that never got chosen as cluster-heads in the last 1/p rounds and mod shows mathematical modulo operator

Nodes that are being elected as heads in round r shall not be taken as cluster head for upcoming 1/p rounds. The nodes with value are higher than the fixed predefined (threshold) will take itself as the head. Then an advertisement message is broadcasted by CH to tell all nearby, that who is appointed as the new cluster-head.

B. Steady state phase

During the Steady-state phase, each node has the ability to turn off its radio. The CH receives the data from member. Oncontrary CHs have to continue their communication status always so the data can be received from others. After receiving data CH will aggregate it and then forward further.

The problems of LEACH algorithm:

a) Misdistribution of cluster head because of the random election strategy of cluster, it may proceed making each cluster head load unbalanced due to early death of cluster heads occurred.
b) LEACH arrangement can only be used on small scale.
c) Assumptions presumed in LEACH such as all nodes have the same topology, same energy and nodes can be told about their residual energy, and so on.
d) In this concept, the cluster head consumes large energy for receiving data, processing the received data and directly sending processed data to the BS node. So, for increasing the lifespan of the network it is important to replace role of cluster head between network nodes.

1.4 WSN and other Technologies

MANET is a superset of WSN but solution of MANET cannot be applied to WSN. The inter-node data flow is different in both. The MANET node has large resources which allow node-to-node communication. On the other hand, WSN's fixed range communication requires data flow through multiple hops of nodes before going at destination. The MANET node is substantially costlier than that of WSN. MANET cannot be deployed on wide range areas on contrast; WSN nodes are cheaper and can cover wider geographical areas. MANET is connected with established infrastructure but WSN need no prior infrastructure. In today's life the cost of hardware is dropping and the size of device inconstantly shrinking. WSN has following the similar trend and way to WSN future depends on its low price, reasonable performance and secure operation. In Figure comparison of WSN is done with other technologies, in terms of computing power and price per unit from the most to least. RFID has both the values as lowest and its function is limited for identification of objects. With the additional capability to process the data Smart Card is taken, a step up from RFID.

WSN is between Smart Card and MANET technology.

Comparison of WSN to the other wireless networked devices is done in more restricted in five ways:

Scalability: Scalability means the network can grow without any limitation.

Energy: Another issue in WSN is its fixed energy. Batteries in the nodes cannot bereplaced.

Communication: We need to find a technique for communication which canprovide security with energy conservation.

Fault tolerance: The main challenge is conservation of limited resources whileproviding the fault tolerance while to network and also the failure of sensor nodes should not affect the overall task.

Routing: Node deployment, energy optimisation, etc plays a vital role in designingof routing protocols for WSN.

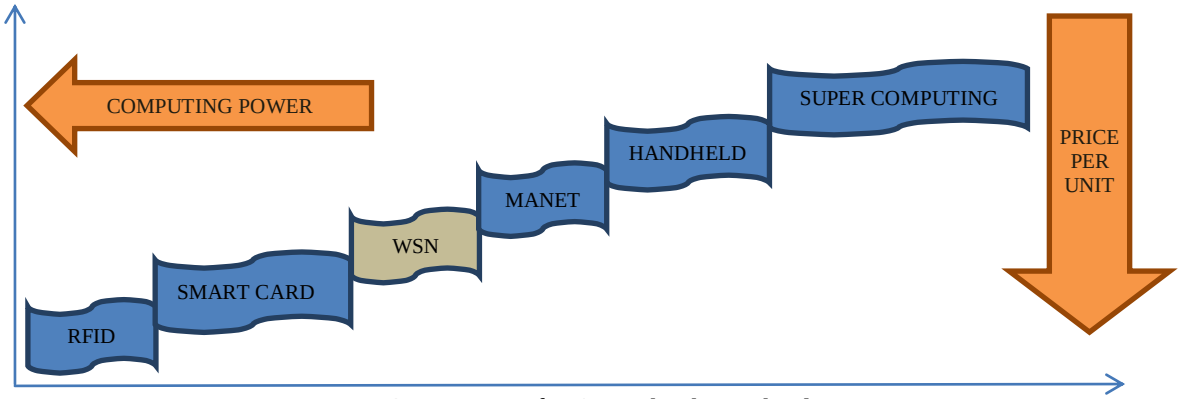

Fig.2 Comparison of WSN with other technologies.

II. LITERATURE REVIEW

WSNs are battery driven cannot be recharged. In multi-hop networks, each node acts both as a transmitter and a receiver. It proves that power failure of single node can cause a significant effect on the network. The most important design problem in WSN is scalability. The sensor nodes in a field may extend to hundreds or thousands. As such, any routing protocol should have ability to work with huge network. The situations due to which nodes gets fail are less power, environmental disturbance or interference or any other physical damage.

The MAC and routing protocols should provide other routes to keep transmitting the data to the base station. On account of WSNs, the conventions work to accomplish the goal of minimizing vitality utilization and to extending the system life expectancy. The studies in regards to with WSN grouping conventions can be found in [32]. The bunching conventions for WSNs can be separated into two classifications: probabilistic and deterministic. In probabilistic bunching conventions, a hub turns into a CH with a specific likelihood. The EEHC [21], HEED [27] and EECS [29], fall in the probabilistic class and PEGASIS [15], and TASC [30] are classified in the deterministic class.

Hu Junping, Jin Yuhui, Dou Liang et al, in [36] conspired a Time-based Cluster-Head Selection Algorithm for LEACH. We call this proposed convention as TB-LEACH. In this, the guideline of TB-LEACH is given with the flowchart and pseudo codes acknowledging TB-LEACH. Re-enactment comes about demonstrate that our calculation beats unique LEACH by around 20% to 30% as far as framework lifetime

JinsukBaek et al, [46] proposed a new mechanism for selection of cluster head andformation scheme for a cluster. In this scheme, every sensor node calculates its relative energy consumption. The outcomes of simulation justify

that the suggested mechanism enhances lifespan of network and provides a pattern for well-balanced energy consumption compared to previously proposed schemes.

ElhamHajian et al**,** [47] proposed another system for the choice of course forinformation transmission. This philosophy depends on learning automata that chooses the course concerning separation from sink and vitality parameters. Re-enactment comes about demonstrate that this technique has been extremely successful in expanding system lifetime.

Yuping Dong et al, [48] proposed applications for observation purposes in view ofWSN. Two pivotal country security applications can be considered as Border security observing and fear based oppressor assault aversion. This calculation parities control utilization among hubs, and in this way draws out lifetime. Reproduction comes about check that our calculation beats the EECCR calculation proposed in.

Xu Long-long et al, [50] presents the remote sensor organize, and examine theissues in LEACH directing convention. It chipped away at adjusting vitality utilization and dragging out the lifetime of sensor system by utilizing calculation. Imitating result demonstrates it is successful.

Xufei Mao et al, [51] demonstrates the sharp steering to improve the systemthroughput, by permitting hubs close-by that catch the transmission of hubs to take an interest in sending bundles, i.e. in forwarder list. We show a vitality productive shrewd steering system, indicated as EEOR. Broad reproductions in TOSSIM demonstrate that our convention EEOR performs superior to anything the notable ExOR convention.

There are several variants proposed for LEACH protocol in the past is discussed further.

2.1 Hybrid LEACH

A remote sensor arrange comprises of hundreds or a large number of hubs thickly conveyed in a more extensive locale. It has been shown that Leach is a vitality productive directing calculation. It arbitrarily chooses a couple of hubs as Cluster Heads and the determination of CH depends on likelihood demonstrate. The probabilistic approach prompts to the making of unequally measured groups which prompts to unevenness in vitality utilization. Different new changes, for example, LEACH-F, LEACH-C, H-LEACH, E-LEACH, V-LEACH have been proposed in LEACH.

LEACH- F**:** LEACH-F is the improved adaptation of LEACH convention withrestricted bunches and pivoting group heads [4].The development of bunches is done just once which are settled, and just the position of group head turns among the nodes. There is no set-up overhead toward the start of each round. Filter F does not permit the expansion of new hubs to the framework.

LEACH-C: W.B. Heinzelman et al, proposed application particular conventiondesign which is known as LEACH Centralized (LEACH-C) [13]. It is an improvement over the LEACH convention. Filter C, utilizes a brought together bunching calculation and a similar enduring state stage as LEACH. Drain is less proficient than LEACH-C since LEACH-C conveys around 40% a bigger number of information per unit vitality than LEACH.

E-LEACH: Energy-LEACH (E-LEACH) [34] enhances the group head segmentmethod in LEACH. It takes the lingering vitality of hub and stamps it as the fundamental metric which chooses whether the hub ought to be a CH or not after the first round. In the event that each hub has a similar likelihood for turning into a CH that mean hubs can be arbitrarily chosen as CHs, in the up and coming rounds. That mean hubs have more vitality will turn into a CHs as opposed to hubs with less vitality.

V-LEACH: V-LEACH [39] is another form of LEACH convention which intendsto diminish vitality utilization. The primary idea driving V-LEACH is that other than having a CH , there is a bad habit CH that overwhelms the position of CH when it passes on. By this, group hubs information will dependably achieve the BS; no compelling reason to choose another CH every time.

H-LEACH**:** Wairagu G. Richard proposed Hierarchical LEACH (H-LEACH) [41]that deals with the idea of minimizing the correspondence separate between hubs for protection of vitality. It utilizes bunching methodology of LEACH amid introductory stages and later it broadens LEACH. The expansion is finished by further bunching the group heads and one of the groups go to goes about as the Master Cluster Head (MCH), for sending information to the base station. In H-LEACH at long last just a single MCH is included for transmition and go about as a main issue.

2.2 PEGASIS

The Power-Efficient Gathering in Sensor Information Systems (PEGASIS) offered in [15] is a change over the LEACH convention. It depends on an ideal chain adjacent. The possibility of the arrangement of bunch and choice of group head is disposed of in PEGASIS. On place of various hubs, a solitary hub in the chain speaks with the base-station. The PEGASIS is made out of two stages: relentless and gathering. The unfaltering stage comprises of a chains developments rather than bunch. In the chain arrangement, an insatiable calculation is utilized where the BS and sensor hubs are worried among those one ends up representing the head. In the information gathering stage, every hub conveys the detecting information to the closest neighbouring hub until the entire information accumulated and handled at head hub from where it is send to the BS. In PEGASIS, the sensor hubs closest to each other are in the chain and they shape a way for transmition. Deferral is brought about in information transmission from the far off hub in the chain.

2.3 Swarm Intelligence Based Algorithm

Another class of calculations, propelled by swarm insight. These calculations depend on the correspondence of an enormous measure of cooperating operator's parallelism. A portion of the classifications are Ant based calculation, honey bee based calculation and thin based calculation and reasonable swarm improvement calculation.

Camilo in 2006 built up an Energy Efficient Ant-Based Routing calculation(EEABR) [33]. In each hub, subterranean insect data is put away in information structure, while the schema of directing table incorporates the past hub, the forward hub, the insect distinguishing proof and timeout esteem.

Saleem and Farooqin 2007, actualized colony steering convention for wirelesssensor network [35] which are produced initially for wired systems

Xiaoming Wang in 2008 built up an Ant Colony enhancement based Location-mindful Routing (ACLR) as another correspondence convention [38] called insect province streamlining based area mindful directing, which depends on the subterranean insect settlement advancement (ACO). The subterranean insect state improvement (ACO) construct directing plan that works in light of the standards of subterranean insect searching conduct, permitting a subterranean insect province to perform complex tasks.[38].Colony is improvement is roused by the scout-enlist arrangement of bumble bees [43]. Ooze shape term is utilized for heterotrophic living being, at provinces and wireless sensor network.

As of now specified some time recently, a remote sensor system can be seen as a "state" of sensor hubs. These hubs are straightforward, with settled limit and rare assets, and can react at the same time. All things considered, they can perform straightforward assignments [44].

Xu in Ji in [52], proposed a PSO based system for bunching in LEACH.

Table 2.Classification and Comparison of Routing Protocols in WSNs.

Routing Protocols	**Classification**	**Power Usage**	**Data Aggregation**	**Scalability**	**Query Based**	**Overhead**	**Data delivery model**	**QoS**
SPIN	Flat / Src-initiated / Data-centric	Ltd.	Yes	Ltd	Yes	Low	Event driven	No
DD	Flat/ Data-centric/ Dst-Initiated	Ltd	Yes	Ltd	Yes	Low	Demand driven	No
RR	Flat	Low	Yes	Good	Yes	Low	Demand driven	No
GBR	Flat	Low	Yes	Ltd	Yes	Low	Hybrid	No
CADR	Flat	Ltd		Ltd	Yes	Low	Continuously	No
COUGAR	Flat	Ltd	Yes	Ltd	Yes	High	Query driven	No
ACQUIRE	Flat/ Data-Centric	Low	Yes	Ltd	Yes	Low	Complex query	No
LEACH	Hierarchical / Dst-initiated /Node-centric	High	Yes	Good	No	High	Cluster-head	No
TEEN & APTEEN	Hierarchical	High	Yes	Good	No	High	Active threshold	No
PEGASIS	Hierarchical	Max	No	Good	No	Low	Chains based	No
VGA	Hierarchical	Low	Yes	Good	No	High	Good	No
SOP	Hierarchical	Low	No	Good	No	High	Continuously	No
GAF	Hierarchical / Location	Ltd	No	Good	No	Mod	Virtual grid	No
SPAN	Hierarchical / Location	Ltd	Yes	Ltd	No	High	Continuously	No
GEAR	Location	Ltd	No	Ltd	No	Mod	Demand driven	No
SAR	Data centric	High	Yes	Ltd	Yes	High	Continuously	Yes
SPEED	Location/Data centric	Low	No	Ltd	Yes	Less	Geographic	Yes

III. CONCLUSION

In this paper, we identified some of the important design issues of routing protocols for sensor networks and also compared and contrasted the existing routing protocols. The system life, number of dead hubs and number of bundle sent to BS influence execution of directing calculation in WSN. The execution of bunch based steering convention demonstrates a few contrasts by shifting life design among hubs and number of dead hubs. We have enhanced the system life yet a certain something; we have watched that hub begins passing on early which is a territory of worry in LEACH.

For network integration or dead nodes criterion Max Energy LEACH performs far better than other algorithms.This can be tended to by considering different parameters of hubs' qualities, for example, remaining hub vitality notwithstanding separation between them while bunching them. This method may postpone early hub demise issue.As our study reveals, it is not possible to design a routing algorithm which will have good performance under all scenarios and for all applications. Although many routing protocols have been proposed for sensor networks, many issues still remain to be addressed.

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