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A Review on Energy Saving Techniques for Wireless Sensor Networks

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***Abstract*—** WSN's are very suitable for remote sensing and monitoring tasks. Generally, hundreds of sensor nodes are installed around a site to execute the native calculations regarding the info collected from the domain. As those sensor nodes are battery operated, it is quite an inimical issue to replace or recharge the batteries. However the major concern while designing a network for the sensor nodes must be energy conservation accessible at each of the sensor node. The broad application of Wireless Sensor Networks (WSNs) gets limited because of the critical energy curbs of the discrete sensor nodes. Because of that logical thinking a large portion of the analysis in WSNs emphasize on developing the energy conscious routing protocols. This can be done by establishing multiple, mobile base stations to extend the allotted span of the sensor network. A lot of research has been done on energy efficiency of WSN's but still there is a need to save the energy of nodes and to save the messages which are being disposed off.

Keywords- *WSN, Energy efficiency, Sensory Nodes.*

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I. INTRODUCTION

WSN is group of Wireless Nodes for monitoring certain phenomena of interested area. Radio signals are used by these sensor nodes for communicating with each other [1]. The basic aim of sensor node is to sense something, monitor it and then explain it.

Sensors nodes are limited in energy, memory and computational capability. The sensor nodes plays an important role in WSN, it may be few in numbers or may be thousands in numbers depending upon the area it covers [2]. To share the data regarding the different events which may occur in surroundings, every single node happens to be in connection with those of others in the network. Radio transceiver and micro-controller are two of the important components of such a node. A sensor node also consists of an electronic circuit. It's responsible for the management of energy source in the course of deployment and transmission. We can say that WSN is quite alike any network having the adopted topology. The Star and the Multi-hop wireless network are two of the examples of WSN topologies. Flooding or routing happens to be a propagation technique for the data flow in between various nodes. The data is collected by the base station from all the nodes, and then that data is tracked to plot conclusions regarding the activity in the field of interest as shown in fig 1.

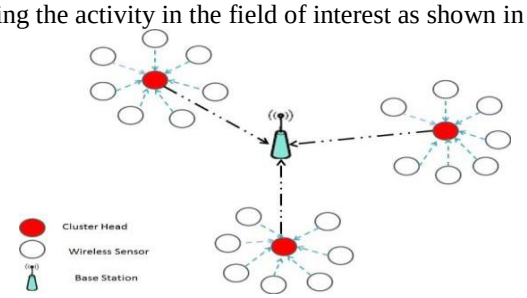

Figure 1: Clustered WSN [2]

II. CHARACTERISTICS OF WIRELESS SENSOR NETWORKS

A Base Station is sort of fusion between one or more elements of the WSN having more resources whether in terms of computation, power or data communication. As these base stations pass on data from the wireless sensor network to the server, they are treated as bridges between the sensor nodes and the end user. Router, which is designed to determine as well as calculate and allocate the routing tables is another major component taken in use for routing based networks [3, 4].

Basically a sensor node is like a minicomputer which is elementary in respect of the components it has as well as the interfaces. These sensor nodes generally possess processing modules having minimal memory, sensors, computational power, power source (like batteries) as well as the data communication tool.

Some of the characteristics of Wireless Sensor Network include:

- Energy consumption restraints for sensor nodes either by having batteries or energy accumulation.
- The potential to tackle with failure of nodes.
- Motility in sensor nodes.
- Data Communication failures.
- Diversity in sensor nodes.

III. APPLICATIONS OF WIRELESS SENSOR NETWORKS

Different applications of WSN are:

- Various applications in the field of Military.
- It can be used in Emergency situations.
- It can also be used in Physical world, Medical and health area.
- It can be helpful in Water/Wastewater monitoring.
- Underwater acoustic sensor systems.
- Traffic Management & Monitoring

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- It can be helpful for Industries.
- It can also work in home networks.
- Automotive.
- Area monitoring.
- Environmental monitoring.

IV. ENERGY MANAGEMENT SCHEMES FOR WSN

The community of researchers as well as the actual users has imparted their attention to WSN. Generally sensor nodes are cell-operated devices, the crucial features preliminary include minimized energy expenditure of SNs, so as to extend the lifetime of network to rational time. The following Figure 2 shows the energy efficient techniques in WSN.

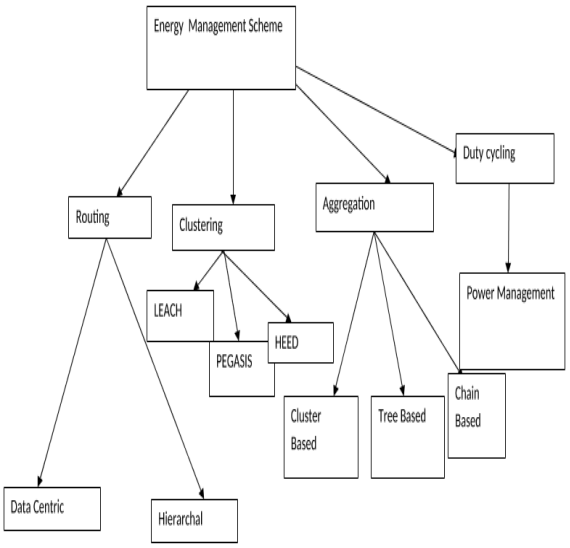

Figure 2: Energy management schemes

A. *Routing Protocols*

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1.) Data Centric routing techniques

In this technique, various queries are directed to stable zones by sink nodes in order to get data from the sensors within that zone. To explain the characteristics of data which are requested from queries, naming based upon attribute is mandatory.

2.) Sensor Protocols for Information from Negotiation (SPIN)

It consists of a bunch of negotiation which is similar in regards with the information circulation protocols that we encounter in WSN. With the help of high level descriptors (known as metadata) the sensor nodes assign name to the data they own during this protocol. The transmission of any kind of redundant data is prevented by using it. This allows SNs to use their energy and bandwidth with efficiency [5].

3.) Rumor routing

Routing the queries which occurred in network to events as well as offering reliability for delivery and tradeoff between setup overhead is the task it carries out. The abstraction which we get from the findings of a bunch of sensor nodes is known as an event which is sort of a local phenomena happens to occur in a particular zone in the network. For the collection of data a request is made in the form of a query which is dispatched by BS and when it arrives at its goal the data starts flowing back to the one who had made the query [6].

4.) Direct Diffusion

This particular query is for data oriented and application aware protocol where aggregation of data is carried out at every single sensor node we have within that network. Unless a request doesn't arrive from the side of BS the sensor nodes don't promote the sensed data, and attribute-value pairs are responsible for naming the data generated by the sensor nodes [7].

B. *Different Clustering Routing Techniques*

Particularly to arrange routers hierarchically, we use the hierarchical routing method. In order to reach the full efficiency of those powerful routers of him the administrator needs a permit from the hierarchical protocol; this acts as a backbone whereas the other slower routers having low power are taken in use for accessing purpose. Some of different hierarchical outing techniques are discussed [8].

1.) Low Energy Adaptive Clustering Hierarchy (LEACH)

LEACH is a TDMA based on MAC protocol. The main aim of LEACH is the improvement in the lifespan of WSNs by reducing the power consumption needed to create and maintain CHs. The operation of LEACH contains several rounds and every round consists of two phases that is Set-up and Steady Phase. The main goal of Set-up phase is to create cluster and select the main cluster head for every cluster by selecting the sensor node utilizing maximum energy. The next phase which is Steady Phase is comparatively longer in terms of duration. On the other hand set-up phase mainly deals with the data aggregation at the CHs and responsible for transmission of data which is aggregated to the Base station [9].

2.) Power Efficient Gathering used in Sensor Information System (PEGASIS)

It's an optimal chain based protocol. The primary ideology here regarding the sensor nodes is to pass on the data which is sensed and transmit it to the neighbors. Further random choices among the SNs are made which will take the responsibility for the communication with BS. It's sort of an assumption that there's a long distance between the sensor nodes and that of BS. Homogeneity can be seen among all the sensor nodes moreover having uniformity in energy works as energy constraint. Cost estimation regarding the energy to transmit a bit holds upon the distance travelled [10].

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3.) Threshold sensitive energy efficient protocol (TEEN)

Both TEEN and APTEEN are threshold sensitive hierarchical routing protocols which have their basis upon the clustering technique seen through LEACH. Generally LEACH is looked for its proactive network applications on the other hand TEEN and APTEEN corresponds to the reactive network applications [11].

C. Clustering – An energy efficient topology control approach

The most common practice done earlier for energy saving in WSN is to select a suitable routing protocols.These protocols implement numerous schemes like multicasting (SPIN) [10], any casting [11](Gossiping), unicasting or Directed Diffusion [12], data aggregation, data compression, data selection (TEEN) [9] and different logical arrangements of SNs present in the network in order to obtain energy efficiency. Among numerous logical arrangements such as ring, tree and trees etc. the most commonly used is clustering. Clustering is an energy efficient topology control technique and data gathering protocol used in WSNs. Logically in a cluster all the SNs are addressed into different classes which have their own access point named as CH. The cluster's individuals forward the data detected by them to their cluster head (CH) either in a single-hop (LEACH) [13] or multi-hop (PEGASIS) fashion [8]. Selection of some SNs as CHs is basically a random choice made by LEACH, in respect of some specific probability function and also shuffles the existing role to balance the power dissipation of the SNs present in the networks. An improvement to this approach was proposed in LEACH-C [14]. It uses an algorithm which is centralized to give better clusters and hence achieves better performance. The main setback of this algorithm is non-automatic cluster head selection and the need that position and remnant power of all SNs must be known. It [15] works on repeated flooding of voting messages in order to find the suitable SN so as to convert it into CH. The data is then aggregated at cluster head using some aggregation function like maximum, minimum, average etc. further transmission is carried out in a single or multi-hop technique (leading to base). So, the contact means between a SN and a distant BS is thus prevented. Such type of reduction in transmission distances for SNs provides huge energy saving in the network.

1.) LEACH

Already discussed in section B(1).

2.) PEGASIS

Already discussed in section B(2)

3.) 1.3.2.3 Hybrid energy efficient distributed clustering (HEED)

This clustering technique stabilizes power between nodes and also plays a role to control Overhead DEMERITS which create a delay and makes scalability limited.

D. Data Aggregation

The TAG (Tiny Aggregation) [16] technique is a data oriented protocol. This approach has its roots linked to those sink sensing nodes moreover it makes use of a routing schema. Further broadcasting is carried out by sink in order to get SNs organized in a routing tree so as to pass its queries. Corresponding to every message there exists a field which specifies the level of the sending SN in respect of the root (level of the root is zero). Throughout the phase of data gathering, because of tree formation, every single parent waits for info (data) from the children and then sends its aggregate up the tree [17].

1.) Cluster Based Data Aggregation

Setup Phase has two main constituents: formation of cluster and selection of cluster head. Once the primal clusters has been formed by the BS, As those SNs possess immobility in nature there will not be any heavy change, whereas in each round the cluster head which has been selected from the same cluster can be different ,the BS will get first divide the network into the form of two sub clusters during the first round, and keeps on dividing those sub clusters in smaller clusters. The base station keeps the repetition of splitting process involved in it until the number of clusters which are to be desired is achieved. Once the algorithm involved in splitting is over, the cluster head will be selected by the base station based on the native info regarding those nodes (for each cluster) [18].

2.) Tree Based Data Aggregation

It's a suitable protocol regarding the sensor information related to TREEPSI. This is quite diverse from the other earlier discussed protocols. Root node will get selected by the WSN in all sensor nodes before the transmission process takes place and the root is set as id=j. To build a tree path there will be two different methods. Sink goes for the computation of the path all by itself and broadcasting the info to the network. The second one corresponds to the building of a native tree structure taking in use of a common algorithm for every single node. In the initial phase root goes for the data collecting process from child nodes using any standard tree iteration algorithm and further they move to data transmission phase after getting over with tree. All the parent nodes (PNs) will take the detected info or say data from the leaf nodes, which aggregates it with their own data and will send it further. The transmission process will go on and on unless all the data gets collected by root node. Later all data is aggregated and sink gets data from the RNs. This whole thing will get repeated unless the RN dies off. Later a new RN will be selected by WSN whose id no. corresponds to j+1.The same process will be repeated again and no difference will be made in that tree path [18].

3.) Chain Based Data Aggregation

This technique reduces energy consumption by using a chain leader. It collects and aggregates data from different nodes and sink gets that data through transmission that utilizes the MHC. In order to minimize energy consumption even

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more, we tend to implement DC (known as data cycling) on chains of level two or three. Nodes that happen to be in those chains use fixed schedules of either active or inactive cycles or for the transmission or intake of data. The chain nodes corresponding to the level three takes data to the CL further the total data is transmitted to the leader (chain leader) of level two, again at this level the leader totals this data with his own and at last it is transmitted to the level one. In this way the transmission of the reduced DP (data packet) to the sink happens [19].

E. Duty Cycling

In general words active or inactive states are set for the radio subsystem of those sensor nodes; even it doesn't require any topology or compatibility related features. Self-governing protocols like inactive/active have their three sub divisions [20] named as on demand, scheduled rendezvous, and asynchronous schemes.

1.) Power Management

Mostly instinctive path is chosen by the On-demand protocols for things like power management. Primary ideology behind this follows the path where a SN is activated only if the other is available to carry out the communication. An important issue that goes along with the on-demand protocols happens to be the situation in which you are needed to notify an inactive SN that the other one is trying to go for a communication. Scheduled rendezvous approach acts like a solution for this. Again the primary ideology behind this one is that they both should wakeup at the same time. Normally, this all goes with the schedule and the time for which a sensor node operates to communicate with others happens to very less. After this, they fall into the inactive state unless the next rendezvous moment arrives. Eventually, this asynchronous inactive/active scheme can be utilized. In asynchronous schemes there's like no restrictions, a SN goes active whenever it desires and even can deal with others. The aim can be attained by the things which have been directed in the inactive/active protocol, so none of the direct sharing of information is required among sensor nodes.

V. PROBLEMS WITH WIRELESS SENSOR NETWORK

WSN has various practices and to make an influence in the real world, we would want additional algorithms and client schemes. In order to design a new scheme or algorithm address some predicaments should be clear [30]. The concerned issues are summarized as below:

- **Security:** The more we are getting dependent on the info we get through the network, the more the risk regarding the security and privacy has been increased. Many techniques including the steganographic and cryptographic have evolved for the safer and secure transmission of the info over a variety of different networks.[31]
- **Resource control**: Finite power of computation and the memory size are two constraints which may influence the storage capacity of each of the SNs. So the protocol should be light in weight and simple. The most imperative limitation binded to sensor network is their limited power resource (i.e. battery), and its Lifespan Efficiency is directly proportional to it. So it's obvious to calculate its lifetime in reference to the power resource. Hence the utilization of the energy I happens to be an imperative matter related to the designing of a protocol. So the delay in communication of a sensor network can be more because of the reason of its finite communication channel in the region which is shared by all nodes for the purpose of transmitting data [32, 35-36].
- **Tolerance of Fault**: In a hostile environment, due to physical damage or lack of energy (power) a sensor node may also lead to get failed. If the failure problem get occur with some, the schemes that happen to be there must acculturate these alterations in the network. For an example, in case of routing or aggregation scheme, suitable paths or aggregation point should be found.
- **Scalability**: It is required in almost all of the practices. The SNs installed in a particular region should be in order of hundreds or more. It's the duty of protocols to deal with such large number of SNs, respond and operate accordingly.
- **Service Quality**: In some of the practices we require sensors that operates in real time which means the moment the data is get sensed it should be delivered to its destination within a certain span of time, otherwise it will be of no use. Hence it's a service quality measure in some practices.
- **Unwatched operation**: It has been observed that there's hardly any interruption for the sensor nodes from the moment it is set, in many of the applications. Hence in case of modification like stuffs if there's any alters then the nodes themselves will be responsible.
- **Node Deployment:** In a real world setting, deploying the WSNs is concerned with setting up an operational WSN [31]. The process associated in deploying can be solely random or predetermined. During the predetermined process, we carry out mostly everything manually whether it's the placing of sensor nodes or routing of data through pre-discussed paths. However, the other case corresponds to the ad hoc infrastructure, which can find better applications like in detection of forest fire.
- **Data Reporting Model:** Sensing data wholly depends upon the practice and the reporting time in the WSNs. This reporting is further classified as time, query or event driven and hybrid. PD (Periodic Data) monitoring corresponds to the time driven one. Switching on to the networks or transmitters, detecting the surroundings and transmitting the info of concern at some particular time interval is foreseen in SNs likewise. Initialization of a particular event or generation of an enquiry by the BS occurs due to sudden fluctuations in the event or query driven models.
- **Node Heterogeneity:** SNs were assumed to be homogeneous in nature. They were believed to possess equal ability in regards of communication, computation or calculation, and power. However, corresponding to its practice a diverse set of SN can raise a lot of problems related to data aggregation [33-34].
- **Transmission Channel:** The SNs responsible for communication are connected via wireless channel in a multi-hop wireless sensor network. The basic issues linked with wireless channel are well inherited in the computation of WSN [35].
- **Data Aggregation:** The main use of Sensing nodes is to gather the info from the environment. The collection of

info by different SNs is converted into and easily understandable format needs by the process of merging or synthesizing. Further transporting this to the BS is another major issue [36-37].

- **Coverage:** The parameter of region acquired is important in WSN designing. Every SN has its own views regarding the surroundings. A SN's view regarding the surroundings is finite in terms of extent and accuracy and it only deals with a particular portion of the surroundings **[**38].

S.No.	Authors	Research Contribution	Journal/ Year	Reference
1.	Srivastav et al.	They explained a protocol based on wide and crossover transmission distance for heterogeneous WSN system. This approach for Heterogeneous Broad Transmission Distance Protocol (HT-BTDP) with scalable approach was released for field-specific as well as for event driven applications of WSNs in IOT (Internet-of-Things). Performance parameters for observation were alive. Node metrics which depicted death of nodes in first quarter, half, third quarter as well as last ones represented the previous available heterogeneous protocols.	Internet-of-Things,2017	[21]
2.	Keynes et al.	They covered important aspects on clustering process in WSN. They discussed hybrid energy efficient distributed clustering technique for dense wireless sensor networks. The Capacity based Clustering Low Energy Adaptive Clustering Hierarchy (CC-LEACH) has been introduced and the results have been calculated against the already existing Low Energy Adaptive Clustering Hierarchy (LEACH) methodology. Results of simulation exhibited fantastic improvement in throughput, delivery ratio for packets and the number of packets received at the base station. Also, the methodology for clustering showed a reduced packet drop, energy consumption and end-to-end latency for dense WSN.	International Conference On Information, Communication & Embedded Systems,2017	[22]
3.	Singh et al.	They presented surveys on the different variants of LEACH routing protocols proposed till date and discussed their extension and working. LEACH protocols are available from single hop to multi-hop communication based on the data transmission from the cluster head to the base station. It further contains comparison of LEACH variants using nine different parameters like energy efficiency, overhead, scalability complexity etc. and also discussed the strong and weak points of every variant.	IEEE,2017	[23]
4.	Shwe et al.	They performed an additional task for network coding during the routing of data in order to attain the additional power saving in the cluster head (CH) nodes. Simulation results displayed the performance of the method which is proposed in terms of the end-to-end delay as well as throughput. In addition, results also displayed a significant improvement for the proposed method in the lifetime of network over other methodologies.	Korean Society Of Information Technonolgy,2016	[24]
5.	Sah et al.	This Paper represents a method for selection of clustering and cluster head in WSN to improve energy efficacy as well as a comparison between LEACH and R-LEACH in terms of network lifetime. LEACH combines the new ideas of energy-efficacy cluster based routing as well as media access together with data aggregation to attain a goal for good performance for system lifetime, latency as well as application-perceived quality.	International conference on Signal Processing, Communication, Power and Embedded System,2016	[25]
6.	Jian et al.	They gave an brief overview over the security preserved for data aggregation schemes and noticed the performance efficiency based upon important performance metrics like confidentiality, data recovery, integrity, as well as support of multiple applications.	IEEE,2015	[26]
7.	You et al.	This Paper reports an unequal clustering scheme, inter-cluster routing	Journal of	[27]

		and cluster radius optimization. Furthermore, this paper introduces an inter-cluster routing protocol based on the improved SFLA (Shuffled Frog Leaping Algorithm). Proposed protocol for the Intelligent Traffic Information Collection (UCPIT) in ITSs aims for balancing the energy consumption of the network. Furthermore, the cluster radius optimization strategy is introduced to avoid the disadvantages of centralized clustering mechanism, and balance the network load to a certain extent.	Information & Computational Science,2015	
8.	Varma et al.	Authors reported a clustering mechanism which divides the entire network in to clusters and multipaths. This mechanism was restricted to only those clusters by which traffic can be distributed only to the cluster without propagating entire network and does not cause delay, energy wastage and increases delivery ratio between nodes. Also proposed CBDR (Cluster Based Dynamic Routing protocol) is compared with existing protocol EQSR (Energy Based QoS Routing protocol) by taking quality of service parameters like End to End delay, packet delivery and energy consumption	Indian Journal of Science and Technology, 2015	[28]
9.	He et al.	They reported a simplification of multi period problem to an equivalent single-period problem, and then further reduced it to a pure-integer programming problem, which can be solved easily in a centralized way. As for the cases without a centralized coordinator among all sensors, author proposes an average consensus-based distributed algorithm (ACDA) to distributive schedule the work modes of all sensors using only local information. Author proves that ACDA converges exponentially fast and reaches global optimum as long as the energy consumption of running the algorithm is ignorable. The proposed distributed solution is also robust against packet drop, node failures, and the changes of communication topology. Extensive simulation results have also shown the effectiveness of the proposed distributed algorithms.	IEEE Transactions On Signal Processing, 2015	[29]
10	Ma et al.	This Paper Presents a novel, reliable information fusion algorithm called reputation-driven information fusion (RDIF). In this work, a clustering algorithm was employed to divide all of the sensor nodes into many clusters. Then, a reputation system was established for each cluster, and an information fusion algorithm driven by reputation values was performed by the cluster head. In future great focus will be employed to design a more suitable reputation system for WSNs and a more lightweight multi-sensor information fusion algorithm.	International Journal of Future Generation Communication and Networking, 2015	[30]

VI. Conclusion And Future Scope

Due to deficiency of power back-up resources available for the sensors, energy efficiency is the most challenging task to make schemes for WSNs. The main aim while designing each of the schemes is to keep sensor operative during data transmission so that lifespan of network can be increased. After surveyed the number of different paper we have summarized the main area of research in WSNs is energy efficiency in terms of data communication, data aggregation and data clustering. Because of vast field we couldn't cover all the associated protocols in WSNs but still we succeed to get useful knowledge about existing WSNs protocols as well as pros and cons of this existing scheme. Also the factors which affect formation of cluster as well as communication between Cluster Heads (CHs).Moreover, in future aggregation of data, data communication and clustering and fusion of data have more scope of research.

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