Comparative Study of Multilayer Architecture to reduce Energy Consumption of Wireless Sensor Networks

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ABSTRACT
Wireless Sensor Network is the collection of sensor nodes uses to gather and transfer the data. The WSN network adopts cluster architecture. In the WSN the clustering techniques are used to build the clusters. In this architecture cluster head is used to collect the data from the sensors and the cluster head process and transfer the data to base station. As per literature survey, there are many challenges and issues in the WSN architecture. The main challenges are energy consumption and data gathering. The clustering algorithms are introduced to overcome these issues. The clustering algorithms make the communication better between the clusters and within the clusters. The algorithms always keep track on the energy consumption, network lifetime, data transfer ratio, etc. The clustering protocols LEACH, PEGASIS, ant colony algorithm, particle swarm optimization (PSO) and multilevel hierarchical clustering algorithm with simulated results are briefly explained. In this paper, the study gaps and problem formulation of multilevel hierarchical clustering protocols are also explained. A methodology is also proposed in this paper to overcome the issues of multilevel hierarchical clustering protocol.

Keywords

1. INTRODUCTION
The current and most popular technology for data collection from the natural or artificial environment is called a wireless sensor network. Wireless sensor network is a collection sensor node that helps to sense the information and gather that information. The sensor network collects the data from various geographical locations and processes that information and pass to the base station via the wireless medium. The sensors work with the batteries. The working phenomena of the sensor network are very simple. There are three main units of sensors that are sensing unit, microcontroller, and radio unit.

Sensing unit + microcontroller (CPU) + radio unit = a large number of applications. [1]

The architecture of wireless sensor network adapts flat structure; it means single-layer planar structure. In this architecture the network size is large. The sensor nodes together make a network that is called as monitoring area. The data collection and processing is done in this area via a wireless medium. These nodes communicate with each other and the data sink through sink node and with the help of internet satellite passed to the user. This process is bidirectional or can as vice versa as shown in fig 1.

![Fig 1: architecture of Wireless sensor network.](image)

There are many issues that are in a traditional wireless sensor network like data lost in communication path energy consumption and energy heterogeneous problems arise. The hierarchical wireless sensor network was introduced to overcome these issues and that is more appropriate. But the wireless sensor network always facing some issues that are discussed as below in the section.[2]

1.1 Issues and Challenges of Wireless Sensor Network
There are many issues and challenges are faced in the wireless sensor network. As per the literature survey the following are some issues and challenges that affect the design and performance of the WSN:

1.1.1 Energy
Energy is the main unit that required performing various operations. The Sensor has batteries that are the main source of energy. Sensors consume the energy while data collection, data processing, and data communication. The sensor also consumes the energy while listening to the medium and it is continuing the process. The energy is also used for the different amount of energy is used when the node component works i.e. CPU, radio etc. with this the power of batteries continues to decrease and need to be changed or
recharges depends upon the type of batteries and sensors. It is not easy or sometimes impossible to replace or charge because of their demographic conditions. This is a huge challenge for the researcher of WSN to design and develop highly energy efficient hardware and software protocols for WSN's. [4,5]

1.1.2 Self-management
After the deployment of wireless sensor networks, it should be able to work independently it means without human intervention. It means it should be able to manage the configuration of the network, maintained, adoption and repair by itself. This is also a challenge, if, in any breakdown condition, the network is not able to perform a data operation and manage itself.[6]

1.1.3 Operating system
Wireless sensor network has its own operating system to operating the various operations. It is important that the WSN operating system should be less than the general operating system. The programmers should develop an easy programming paradigm. With this, the developer will be concerned with the application logic instead of low-level hardware issues like scheduling, preemting and networking. There is a number of wireless operating system that is developed for operations. TinyOS, mantis operating system and nano-Qplus is some of the WSN operating systems.[7]

1.1.4 Mac layer issues
MAC layer has some operations to perform like collision control, packet overhead and idle listening that is the issues. These issues cause a direct impact on energy consumption as the issues leads to the wastage of energy. Error control technique carries high computing power requirement and it is not implemented power saving techniques.[8]

1.1.5 Quality of service
The level of service is provided by the sensor network to their user is called quality of service. There is various real time and critical application quality of service is mandatory. It is not easy to provide quality of service because there may be constant change in the network topology and the available state information for routing is inherently imprecise. To achieve a minimum required QoS the sensor networks need to be supplied with the required amount of bandwidth. While aggregating data from nodes to base station, it’s quite obvious that the traffic is unbalanced. There are some QoS mechanisms that should be designed for an unbalance QoS constrained traffic. In many routing algorithms to meet the desired quality of service sometimes there are compromised with the energy. The multi hop reduces the energy amount that consumed while data collection the overhead associated with it that may slow the process of packet delivery. The QoS standard of WSN should always design in such way that able to support scalability. WSN networks are most flexible so removing and adding nodes should not affect the QoS of the WSN.[9]

1.1.6 Security
Security is very important and quite challenging for the WSN. Security in WSN needs at every step like for surveillance, building, monitoring, burglar alarms and also critical systems not only for battlefield application. Some security parameters are present so that system must be protected. To protect the information that is traveling between nodes and base station confidentiality requires. Confidentiality always takes care of spying and spoofing activities. Every sensor node of the wireless sensor network has the ability to scan the data and validate the requires and correct data. Sensor nodes have information about some trusted sender. But some attacker nodes try to steal the identity of trusted nodes and transfer the data or can change the data of the sensor nodes. Data integrity is the important parameter and should be maintained. Data ought, and not change and exact information must be transferred to the client end. There are a number of threats that affect the wireless sensor network and alter or spoofing the data. Sinkhole attacks, Sybil attacks, denial of service attack and jamming are the some of the WSN attacks.[10]

1.1.7 Architecture
The architecture of WSN is heterogeneous. There are always some set of rules and guidelines that help to implement and in a functionality of the wireless sensor network alongside an arrangement of interfaces, protocols, functional components and physical hardware. The absence of wireless sensor network can increase the conflicts and limit the features of WSN. The architecture of wireless sensor network must be durable and versatile. The architecture should be so flexible and adaptable so that the quality of service does not affect by increasing or decreasing the sensor nodes. The architecture should meet the requirement of the set of communication protocols and adhere them.[11]

1.1.8 Data collection and transmission
The main objective of sensor nodes is to gather data. Data sensed by the sensors periodically from the encompassing environment and prepare it and transmit data to a base station or sink nodes. The process of data gathering is the collection of data and data transmission to the sink node. It is the normal situation while data collection having redundancy. The issues with data gathering and transmission process are the sensor nodes collect the redundant data and transfer that redundant information that causes the wastage of energy. The energy can be saved if the elimination of redundant sample will be ensured.[12]

1.1.9 Physical attacks and security
The wireless sensor network deployed in the open environment. The sensor nodes have to deal with adverse conditions and bad weather. The physical security of the sensor must always be ensured. The physical attack on the senses are happened and security from these attacks must be ensured. The adverse weather condition and sensor stealing or replacing are the major physical attacks. The attacker can try to
replace the sensor node with malicious nodes and attack on the system application.[13]

1.1.10 In network processing
The communication cost in the WSN increased because of redundancy. There is some algorithm that is used to decrease the communication cost. These algorithms remove or reduce that increase redundancy and forward traffic of no use. The nodes can inspect the data that are forward by them and are measured average or directionality for instance of reading from different hubs. In the general case the sensing and monitoring application registers the nodes with similar values. The techniques for in network data aggregation and mining inspired by the data redundancy that caused by spatial correlation between sensor observations.[14]

1.1.11 Heterogeneity
WSN is a group of nodes, all nodes are not same and also do not have the same capability. The capability of nodes might be considered on the basis of power. Some nodes are more powerful that require more resources while some nodes are less powerful and require less resources. The best example of heterogeneity is cluster architecture. It’s this architecture the cluster head is the powerful node collect the data from the less powerful nodes. When two WSN communicate with each other that are truly different that is called heterogeneity. In WSN to manage efficient information exchange within the system and nodes the unified communication interface will be required.[15]

1.1.12 Synchronization
The working in the wireless sensor network with the help of time synchronization. A clock is always synchronized in the WSN so that the entire sensor can work on the same clock. It provides a common timescale for local clocks to the nodes. To prepare and analyze data correctly and forecasts future framework behavior global clock is used. Global clock synchronization requires by some WSN applications like environmental monitoring, route direction, vehicle tracking, etc. the equipment like GPS receiver or NTP(network time protocol) that are energy hungry equipment utilize more energy while synchronization between the sensors. The synchronization should be correctly implemented in the applications. As the same synchronization protocols are so highly accurate so the resource requirement is more.[16]

The major issue is energy consumption. The sensor utilizes the most of their battery source in data gathering and processing sensor hasn’t proper energy sources that can complete the data operation and result in the data loss. Due to sensor location, sometimes it is impossible to change and charge the sensor node’s batteries. To save the energy in the sensors data aggregation is provided. Data aggregation is a process of gathering and aggregating the useful data. It is methodical to diminish the failure and overlap problems. Increasing the network lifetimes by using fewer resources, i.e. battery is the main objective of the data aggregation.
The main reason of energy consumption is collecting and transferring data. To utilize the energy an appropriate routing is required. In WSN the routing protocols introduced to save the energy of nodes and increase the routing efficiency. Clustering is a technique that increases the lifetime of WSN’s by reducing power consumption. To increase WSN’s energy efficiency the concept of hierarchical routing is used. In this approach, a number of sensor node collectively from the cluster. In every cluster there is cluster head, that node is used to conduct the data collection and data compression. The amount of data that sent to the base station will increase by using techniques and that make the resources energy efficient. In the cluster, during the data transmission in the distance the idle node can go into sleep mode and save energy for further use.

There are many data aggregation protocols are available like LEACH, PEGASIS, Ant Colony algorithm, Particle Swarm Optimization (PSO) and clustering based hierarchical routing. Few of them are also discussed as below.

1.2 Energy Efficient Techniques
The following are the energy efficient techniques:

1.2.1 PEGASIS
PEGASIS (Power-efficient Gathering in Sensor Information Systems) is an algorithm that is basically greedy chain-based. It is a power-efficient algorithm and relates to the LEACH protocol. There are certain features of this algorithm, which are:

1.2.1.1 The distance of the base station from the sensor nodes is very far.
1.2.1.2 All the sensor nodes present are similar and there is a limited amount of the energy present within them.
1.2.1.3 The sensor nodes present within this network are not mobile[17].

There are two strategies within the PEGASIS namely, chaining, and data fusion. The leader of the chain in this algorithm can be selected from any node and each node can once be selected as the leader. The greedy algorithms are utilized for constructing the chain with the help of the deployment of the sensor nodes.

1.2.2 Leach
The hierarchical protocol which transmits nodes to the cluster heads is known as the Low Energy Adaptive Clustering Hierarchy (LEACH). Its two phases are explained below [18]:

1.2.2.1 The Setup Phase
The organization of clusters and selection of cluster heads is done within this phase. With the help of a stochastic algorithm, within each round, it is checked by each node whether it will be selected as a cluster head or not. Once the node is selected as a cluster head, it is not selected second time.
1.2.2.2 The Steady Phase
The data are transmitted to the base station in this phase. For reducing the overhead across the network, the time duration of this phase is longer than the previous one.

1.2.3 Ant Colony Algorithm
The natural behavior of the ants that communicate with each other through the pheromone is utilized by this ant colony algorithm. The mobility of the ants is decided by the pheromone that is a chemical substance released by the ants. The length of the branches is not known when there is not pheromone released on them at the beginning. The pheromone is released at a higher rate after the shorter range is detected [19]. The ants visit numerous times on the similar path and this factor depends upon the amount of pheromone released by the huge number of ants. This will help provide a positive feedback regarding that path.

1.2.4 Particle Swarm Optimization (PSO)
The development of PCO algorithm is based on the social behavior of the group of birds. A swarm provides numerous solutions for a specific optimization issue with the help of PSO. The particle location is checked here, which further helps in providing a fitness function that has the best evaluation. Initial parameters are given in an irregular manner for each particle which is the initial step of PSO. The information related to the good old individual position and the global best optimum location is utilized for increasing the probability of providing an optimum solution space. This will result in providing a better fitness space within the algorithm [20].

1.2.5 Multilayer Hierarchical Clustering Protocol
The multilayer hierarchal clustering protocol is energy efficient and loads balancing in the nodes of wireless sensor network. The architecture of multilayer hierarchical clustering protocol is shown in fig 2. The following is the protocol detail that is defined:

In this protocol, the author introduced the innovative approach and divides the cluster into virtual circles with the variable radius. The size of circle depends upon the circle distance from the axis. The circles are again divided into the clusters. Each cluster has a leader node that is used to collect the data from the neighbor nodes and transfer to the cluster head. The simulated results of the algorithm are a comparative analysis with the other clustering protocols. And with these, the network lifetime increased from the comparison algorithms that are LEACH, TCAC, and DSBCA by 73%, 52%, and 21% respectively [3]. It also makes the protocol energy efficient and balances the load in the all over network. In this protocol, the nodes having maximum energy with the proper position are selected as the cluster nodes. Like other many clustering protocols does multilayer hierarchical cluster protocol also cyclically change the cluster head. There criteria that are followed selecting cluster head that are node energy level, a degree of the node from the parent node within a specified radius and number of volunteer nodes within the cluster. The working of multilevel hierarchical architecture is as given below:

Step 1: cluster head selection
In the multilevel architecture, the area is divided into virtual circles with different radius. A balanced cluster distribution helps to create balanced cluster head. The selection of cluster head is based on some factors like energy, distance, and the protocols. The energy of nodes is always verified before selecting cluster head. Long distance also avoided for cluster head selection. Long distance also creates conflicts. The cluster size in this architecture varies from each other. The outer cluster is larger than the intra cluster. In the cluster, some of the net area of the cluster is not considered to select the cluster head. Because of the nodes on the border and corners of the cluster. The cluster nodes always consume more energy than the other nodes. The degree of nodes is calcite on the basis of energy and distance from the base stations. Nodes with high degree are suitable for being cluster head. The algorithm is designed for selecting cluster head selection so the less cluster head will select. The algorithm reduces consumption and increases lifetime.

![Fig: Architecture of multilayer hierarchical clustering protocol](image.png)

Step 2: leader node selection:
The energy of intracluster communication depends upon the cluster size and centrality. The size of clusters in this architecture is different. It varies from one to another. The size of clusters in the architecture is different. It varies from one to another. If the cluster size is huge that affects the energy consumption. And in the huge cluster the distance between ordinary nodes to the cluster head. The average distance between the clusters head and ordinary nodes and density of nodes always affect. To overcome these issues the leader nodes are appointed.
The leader nodes collect the data from the border nodes and transferred to the cluster head.

**Step 3: next hop selection:**
In order to send data, the next hop is determined. If there is no leader node in the cluster then each ordinary node of the cluster will be considered as its next hop. To send data ordinary node check and select the nearest node that can be cluster head, leader head or nodes. The cluster head is considered as the next hop. To send data ordinary node check and select the nearest node that can be cluster head, leader head or nodes. The cluster head is considered as the next hop by each leader nodes. The leader node selects the nearest cluster head with the smaller radius and closer to the base station as the next hop In order to send the base station. After transmission of data, each cluster send acknowledgment to leader nodes and ordinary nodes on TDMA program.

2. **SIMULATION RESULTS OF ALGORITHMS**
The following are the simulation results of multilayer hierarchical clustering protocol, these results are comparative analysis with the LEACH, TACA and DSBCA protocols. The following are the results on the different parameters in MATLAB.

2.1 Network lifetime
The values suggest that proposed protocol has extended network lifetime or stability period as 73, 52 and 21%, respectively, relative to LEACH, TCAC and DSBCA protocols.

2.2 Network energy consumption
The percentage of network residual energy after the death of the first node for LEACH, TCAC, DSBCA and proposed protocols is 44, 29, 21 and 8%, respectively. These values indicate that the energy consumption, distribution in a proposed protocol is better and more suited. In fact, instability period reflects less the uniformity of energy consumption between network nodes and it verifies the load balancing across the network for proposed protocol.

The main focus of this paper reviews a proposed hierarchical clustering technique that is energy efficient and load balancing technique.

3. **BRIEF LITERATURE SURVEY**
To dissect the issues, literature survey has to be carried out. During this research work, following study has been carried:

A.Jayanthiladavei, S Suma and T.Lalitha [1] in this paper the author describe system containing a few moment remote sensor hubs which are composed in a thick way is called as a Wireless Sensor Network (WSN). Each hub evaluates the condition of its surroundings in this system. The evaluated comes about are at that point changed over into the flag shape with a specific end goal to decide the components identified with this system after the handling of the signs. Based on the multi jump system, the whole information that is gathered is coordinated towards the extraordinary hubs which are considered as the sink hubs or the Base Station. The client at the goal gets the information through the web or the satellite by means of passage. The utilization of the door is not exceptionally vital as it is dependent on the separation between the client at the goal and the system.

Xuhui Chen and Peiqiang Yu [2] describe system containing a few moment remote sensor hubs which are composed in a thick way is called as a Wireless Sensor Network (WSN). Each hub evaluates the condition of its surroundings in this system. The evaluated comes about are at that point changed over into the flag shape with a specific end goal to decide the components identified with this system after the handling of the signs. Based on the multi jump system, the whole information that is gathered is coordinated towards the extraordinary hubs which are considered as the sink hubs or the Base Station (8S). The client at the goal gets the information through the web or the satellite by means of passage. The utilization of the door is not exceptionally vital as it is dependent on the separation between the client at the goal and the system.

SamanSiavoshi, Yousef S. Kavian and Hamid Sharif [3] presents an clustering protocol of load balancing which separates the entire network to the virtual circle with variable radiuses. The author’s protocol utilizes an inventive design in intra cluster communication. In this protocol, radius of each virtual circle and the size of each cluster will increment with the expanding separation from the base station, in such way that cluster size of each circle will be distinctive with the clusters of other circles. In each cluster, leader nodes are in charge of collecting and compressing information from their ordinary neighbor nodes and sending them to cluster head. Recreation comes about exhibit that proposed protocol expands arrange lifetime in examination with protocols LEACH, TCAC and DSBCA by 73, 52 and 21%, separately. It also makes energy efficiency and load balancing across the network.

AsmaeBilalat, Anas Bouayad, Nour El HoudaChaoui and Mohammed El Ghazi [4] describe the appearance of low-control remote sensor systems, an abundance of new applications at the interface of the genuine and computerized universes is rising. A circulated registering stage that can quantify properties of this present reality, figure savvy inductions, and instrument reactions, requires solid establishments in circulated registering, counterfeit insight, databases, control hypothesis, and security. Before these smart frameworks can be sent in basic foundations, for example, crisis rooms and powerplants, the security properties of sensors must be completely caught on. Existing insight has been to apply the customary security models and systems to sensor systems. Be that as it may, sensor systems are not customary registering gadgets, and as a result, existing security models and strategies are ill-suited. In this position paper, we make the primary
strides towards creating a thorough security demonstrate that is custom fitted for sensor systems. Fusing work from Internet security, omnipresent registering, and dispersed frameworks, we plot security properties that must be considered when planning a secure sensor organize. We propose challenges for sensor systems – security obstructions that, when overcome, will move us nearer to diminishing the partition amongst PCs and the physical world.

Gurbinder Singh Brar, et.al [17] proposed in this paper, a directional transmission based energy aware routing protocol named as PDORP is proposed. The properties of Power Efficient Gathering Sensor Information System (PEGASIS) and DSR routing protocols are combined in this newly proposed protocol. The performance analysis shows that there is a reduction in the bit error rate, delay and energy consumption within the network. There is also an improvement in the throughput which results in providing better QoS and which further results in increasing the lifetime of the network. For the purpose of evaluating and comparing the performance of both the routing protocols, the computation model is used.

4. GAPS IN STUDY OF MULTILEVEL HIERARCHICAL CLUSTERING ALGORITHM

The algorithm was design for load balancing. The gaps in a study are energy consumption and load balancing. The protocol divides the whole network in virtual circles with a definite radius. In the center of the circle a base station is there and cluster head pass the information to that base station. The cluster size increase with increment in its radius. The nodes that are in these protocols are ordinary nodes, leader nodes and cluster heads. Leader node is responsible for collection and compressing the data from the ordinary nodes to cluster head. Then the outer cluster heads pass information to intra Cluster head and with this data pass to the base station. The gap is in this protocol the intra clusters nodes are very busy to pass the information to the base station from outer cluster and also collect their own data and pass that data to base station. This will decrease intra cluster energy and decrease network lifetime. To overcome this gap a methodology is proposed.

5. PROBLEM FORMULATION FOR GAPS

The wireless sensor networks is the type of network in which sensor nodes sense the information and pass it to base station. The size of the sensor nodes are very due to which battery of the node is very limited , in the previous times various technique has been proposed to reduce energy consumption in the network. The clustering is the most efficient technique which reduces energy consumption of the wireless sensor networks. In the base paper, technique is been proposed in which cluster heads are selected from the network, the nodes which are not cluster head will be applicable to be selected as leader node. The leader node will pass the information to cluster head and then cluster head will pass the information to base station. In this work, further improvement will be proposed to include new condition for the data aggregation. The proposed improvement may leads to increase lifetime of the wireless sensor networks

6. PROPOSED METHODOLOGY

The multi-level is the clustering algorithm of wireless sensor networks in which cluster heads are selected from the network. The nodes which are left behind are the volunteer nodes for the selection as the leader node. In the proposed work, the gateway nodes are deployed in the network. The leader nodes aggregate information from the sensor nodes and pass the information to cluster head. The cluster head will pass the information to the gateway node which sends the data to base station. The cluster head sends data to gateway node which has minimum mac value. The mac value is assigned to the gateway nodes randomly. The proposed technique leads to the reduction in the energy consumption of the network.

7. CONCLUSION AND FUTURE SCOPE

Wireless sensor network is the most popular and current technology. The technology works with the sensor and has much implication in a local and remote area. The data is gathered, processed and transferred by the sensor with the help of the wireless medium. There are many issues and challenges are there in the wireless sensor network, some of them are explained in this paper. The main issues of WSN are energy consumption , to overcome the energy consumption issues there are many clustering protocols are introduced. The clustering protocols are LEACH, PEGASIS, Ant Colony algorithm, Particle Swarm Optimization (PSO) and multilevel hierarchical cluster protocols and explained. The gaps and problems formulation for and multilevel hierarchical cluster protocols are also elaborate. In the future scope, the gateways will be implemented in the intra clusters of multilevel hierarchical architecture. The algorithm will be implemented with gateways to overcome these issues.

8. REFERENCES


