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Wireless Sensor Network configuration protocol

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ABSTRACT

The wireless sensor network is the decentralized kind of network which allows sensor nodes to join or leave the network according to their wish. The implementation of sensor network is done at far places and they are small sized. Thus, energy consumption becomes the main issue of WSN. The data whose collection is done from the aimed environment, is transmitted directly to the main station due to the restricted energy of sensor nodes. The sink node receives the data transmitted from various sensor nodes. The decision-making process is deployed by recognizing and eliminating the similarity among the data of diverse sensor nodes. In addition, the sink makes the deployment of obtained data locally as well as transmits these data to the networks which are executed far away. The existing research work employs CTNR, an energy efficient protocol that is capable of enhancing the duration of WSN.

The configuration of a wireless sensor network often involves protocols like zigbee is commonly used for low-power, short-range communication in various applications including wireless sensor networks, home automation, industrial control and healthcare. Configuration may include addressing, data reporting intervals, and network parameters.WSN routing protocols can be divided into, hierarchy-based protocols, and location-based protocols. Sensor nodes are used in WSN with the on board processor that manages and monitors the environment in a particular areas. They are connected to the base station which acts as a processing which acts as a processing unit in the WSN system.

KEYWORDS: - *microcontroller, parameters, periodically, broadcast.*

Wireless sensor networks (WSNs) belong to a new type of wireless networks that are getting popularity with a large number of civilian and military applications. A wireless sensor network (WSN) refers to a wireless network that comprises distributed autonomous sensor devices so as to monitor physical or environmental conditions. AWSN is composed of a set of connected small sensor nodes, also known as motes. These node share information and data after establishing communication with each other. These nodes gather information of environmental parameters such as temperature, pressure, humidity or pollutant, and relay this information to a sink or base station. The base station further forwards this information to a wired network or triggers an alarm or an action, according to the sort and dimension of data observed. In a wireless sensor network, all nodes are generally deployed with a radio transceiver, a small microcontroller, and a power source or battery [1]. The most constructive property of these networks does not emerge from the power of the individual sensor devices; it emerges from the whole range of interlinked sensor devices. Therefore, the scale of these networks is generally vast from the standpoint that they possess several thousand nodes and they are suitable to be self-arranging, in order to be reliable. As a wireless sensor node is typically low-priced, a WSN is expected to have a significant number of nodes. Figure 1.1 shows a typical Wireless Sensor Network

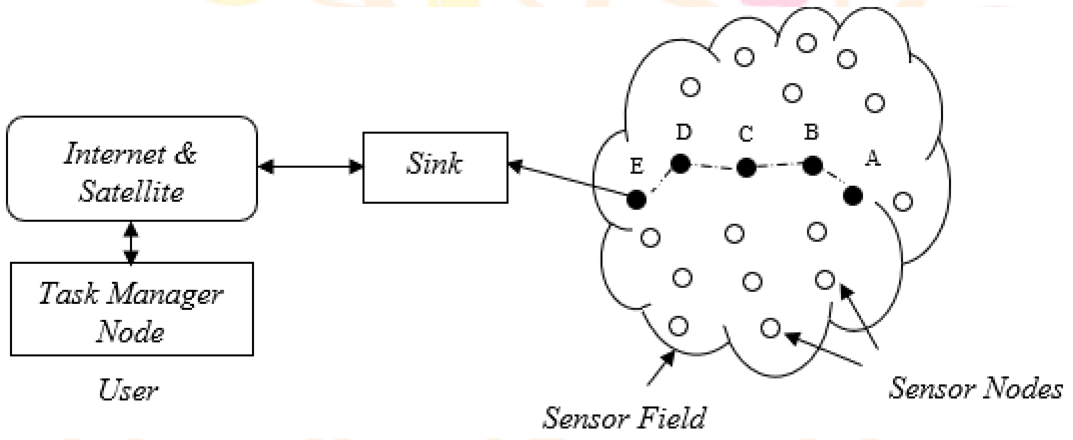

Figure 1.1: Wireless Sensor Network

In general, sensor nodes use a multi-hop approach to interact with each other. The passage of information and data halts at specific nodes termed as sinks or base stations. A sink or base station typically links the sensor network to an immobile network such that the sensed data could be distributed for more processing. Usually, sinks have improved potentials over simple nodes to accomplish composite processing. This validates the fact that base stations are equipped with more sophisticated processors including PCs/laptops with more RAM memory, secondary storage, battery and computing strength as they can accomplish more operations as compared to typical sensor devices. It is important to note that a major shortcoming of sensor networks is energy usage, which is actually the result of communication among nodes [2].

1.2 Energy Consumption in WSN

Sensor nodes are developed with less difficulty for the implementation at large scale at an alleviated cost. The major issue in Wireless Sensor Network is energy that assists in obtaining a longer life span during their execution on finite battery reserves. The main source of power utilization is to transmit the multi-hop packet across the wireless networks. In the Wireless Sensor Networks, the crucial task is that a less energy must be consumed especially in sensor networks that have included the nodes and taken as a lightweight having a finite battery power. Different network architectures including OSI and Internet are basically functional models which are organised as layers at which the services are offered to the layer above through the layer. The quality of the service metrics of network like delay, throughput, availability, reliability and even security can be utilized to compute a network [3]. But, in case of EC a great complication is occurred due to the evaluation and optimization of the network is considers as a comprehensive model in which the energy consumption is considered hardly exists. The duty cycle of the wireless sensors is controlled by in dynamic way to mitigate the EC. The issue of managing energy management is become very complex especially in various mission-critical sensor applications. The requirements of these applications are that a predetermined level of sensing is maintained at the time of communication performance constraints. Thus, the issue is raised for developing the routing protocols that have scalability and can be executed in effective manner for a wide range of performance constraints and design requirements.

For the future of Wireless Sensor Networks fig.1.2 show the energy consumption model, these protocols would be constructed.

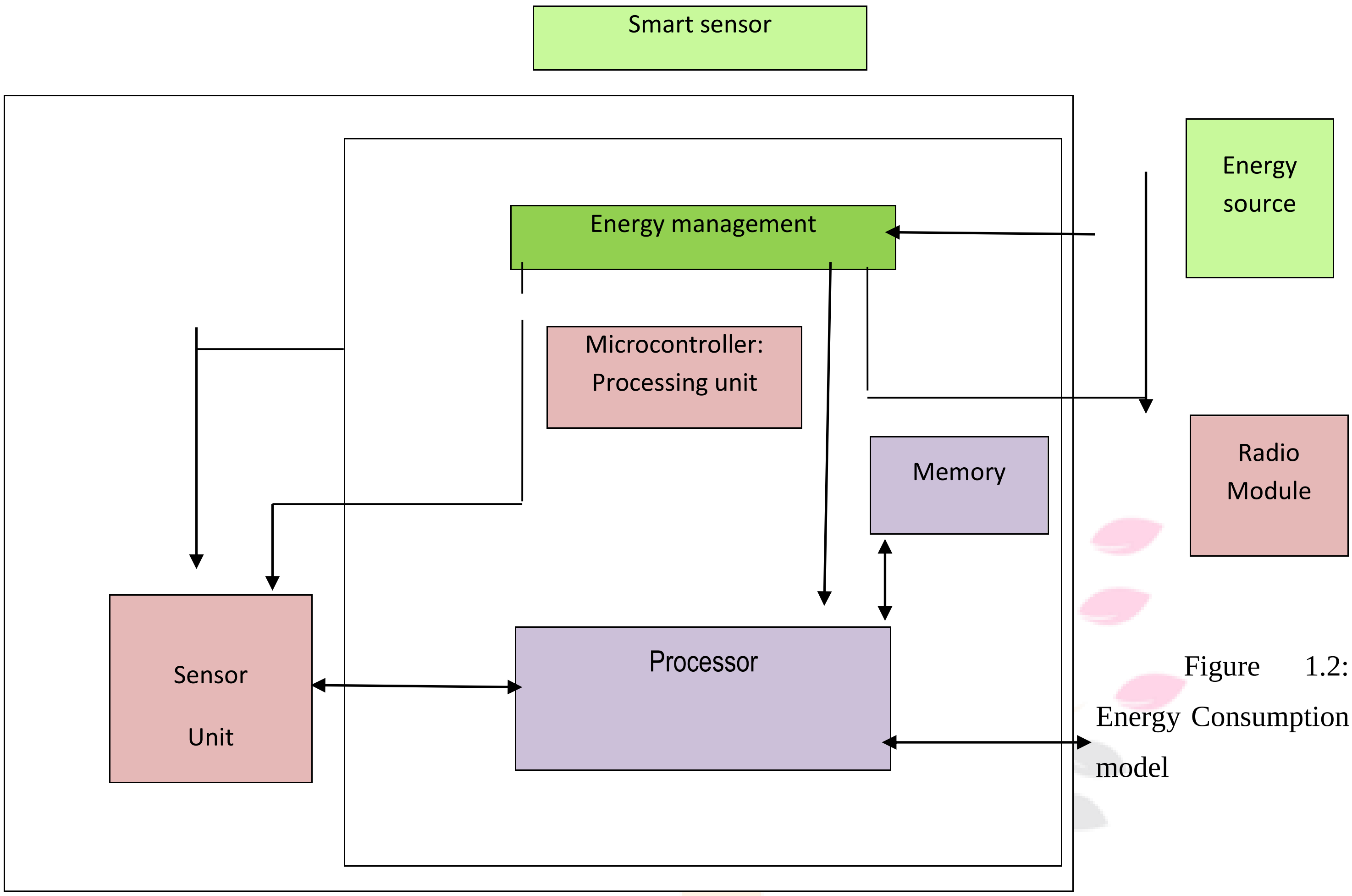

Figure 1.2: Energy Consumption model

1.3 Routing Protocols in WSN

Routing is one of the most crucial processes in sensor networks due to several factors such as high-power consumption, packet overhead control, and end-to-end delay. Therefore, there is the need of a successive routing approach to reduce power consumption and prolong the service time of sensor network. The quicker the routing process, the lengthier is the service time of sensing device and the lower is the power exhaustion. Therefore, designing competent routing algorithms for WSN is an important task [4]. The energy efficient routing algorithms for WSN can be classified as:

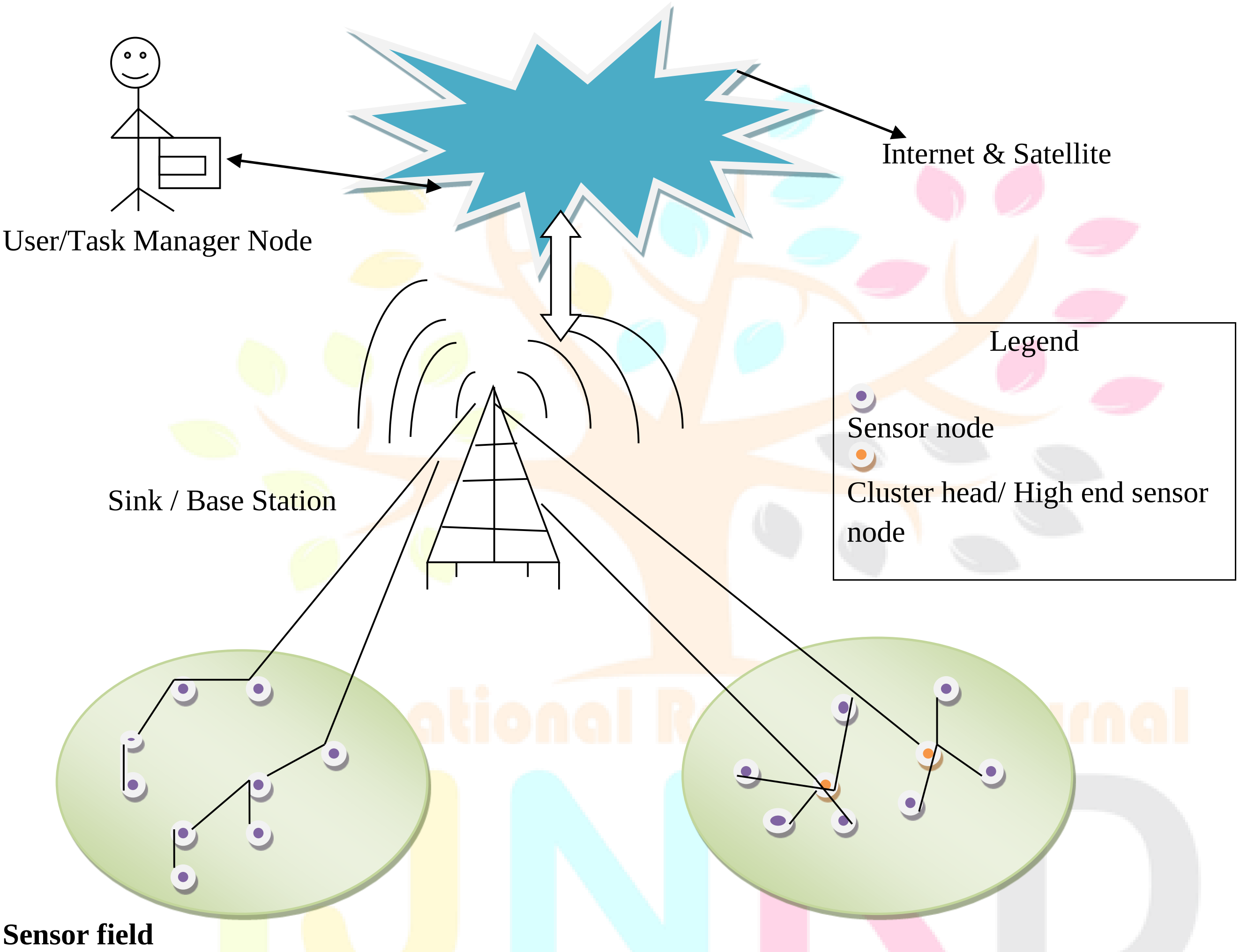

Figure 1.2.1: Routing Protocols For WSN

1.3.1. Location-based Protocols

These protocols consider the effect of physical distance and nodes' distribution to be important for network performance. These types of protocols follow two major assumptions. Firstly, these protocols assume that all nodes know the location of its own network neighbours. Secondly, it is assumed that information about the status of the destination is provided to the message source. This approach uses available query routing tree without establishing more communication channels to transmit queries locally in geo-aware sensor networks. These algorithms need nodes to periodically broadcast HELLO messages to let neighbouring nodes to know their location. The location-based routing approach is quite fascinating as it does not need any routing tables for its operation. In addition to this, all operations are strictly local when the location of the destination is acknowledged. This means that all nodes just have to maintain record of their direct neighbour.

Two well-known location-based protocols have been described below:

i. Geographic Adaptive Fidelity (GAF): GAF is an energy-efficient routing protocol. This protocol favours energy conservation [5]. The architecture of this protocol is inspired from an energy model that acknowledges energy consumption because of the receiving and transferring of packets with idle (or listening) time wherein a sensor radio turns on for detecting the incidence of approaching packets. This protocol is concerned with the idea off switching off needless sensors while maintaining a constant rate of routing reliability. This protocol divides sensor field into grid squares. All sensors make use of their location information, provided by GPS or other location systems, for associating themselves with a specific grid in which they reside. GAF uses this sort of association for identifying the sensors of matching features to broadcast packets.

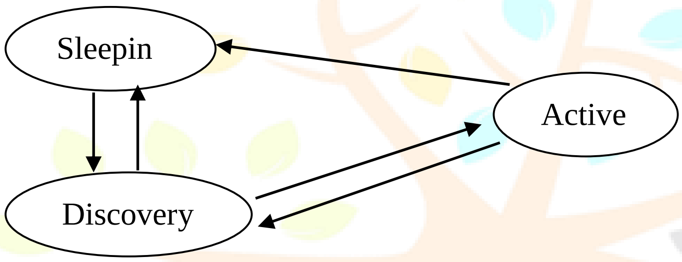

Fig. 1.3.1: State transition diagram of GAF

Figure 1.3 shows the state transition diagram of GAF. There are basically three states in this protocol, namely, discovery, active, and sleeping. A sensor after entering in the sleeping mode, switches off its radio to save energy. In the discovery state, a sensor shares discovery messages to acknowledge other sensors within the same grid. A sensor despite of being in the active state periodically sends its discovery message to provide information to corresponding sensors regarding its state. The time consumed in every state can be tuned by the application according to several aspects, for example its requirements and the sensor's dynamics. The main objective of this protocol is to prolong the network service by reaching the same position on the basis of principles according to which rank is assigned to sensors in every grid. The ranks are assigned according to the energy leftover in the sensor nodes. Therefore, a high-ranking sensor node can handle routing within its equivalent grid. A higher rank sensor node is believed to contribute in prolonging the network life span [6].

ii. Geographic and Energy-Aware Routing (GEAR): GEAR is another location-based energy-efficient routing protocol. This protocol was designed for routing queries to target areas in a sensor field. In this protocol, the sensors may be deployed with localization hardware, such as, a GPS unit or a localization system to find their current locations. Moreover, the sensors know about the dreaming energy along with the positions and leftover energy of its every neighbouring node. This protocol makes use of geographical information-based theories for sensor selection so that a packet can be forwarded toward its destination. Afterward, this protocol distributes the packets in the target area using a recursive geographic forwarding algorithm [7].

iii. Graph Embedding for Routing (GEM): GEM is described as allocation-based routing protocol that attempts to allocate labels to sensor nodes in an exceptionally distributed way. Nodes can perform message sharing only by recognizing the labels of their immediate neighbouring nodes. GEM uses virtual coordinates rather than real physical coordinates. This algorithm is composed of two elements that are defined as follow:

- The Virtual Polar Coordinate Space (VPCS): The first step for building a VPC is to embed a ringed tree. In order to build a spanning tree, there is the need to define a root node. Afterward, every node is assigned an angle range, using which angles can be assigned to its sub trees. According to the size of each child's sub-tree, each node divides its angle range into its children [8]. The centre of mass and the average location of all nodes are calculated for each sub-tree and it is further propagated to the tree's parent.
- The Virtual Polar Coordinate Routing (VPCR):VPCR routes from any node to any point in the VPCS. A level and angle are used to define a point.

The major benefit of GEM is that it allows messages to be propagated competently throughout the network, whereas each node is required to identify the labels of its neighbouring nodes.

1.3.2. Data Centric Protocols

The basic difference between this type of protocols and protocol of other type is that protocols in this category transfer data straightway from source to the sink (base station). All nodes at the source forward the data to the sink auto Nomo us land let these data-centric protocols to do the processing of this data. These protocols aggregate data generated from numerous source sensor nodes at the time of its need to transmit it between source and base station. These protocols are highly energy efficient. Two prominent protocols in this category are described below:

i. Sensor Protocols for Information via Negotiation (SPIN): The SPIN family of protocols are based on two fundamental ideas. First, it is necessary for sensor applications to establish communication with each other regarding their pre-existing data and the data they still want to get, for operating efficiently and saving energy. Second, network nodes should essentially observe and adjust to variations in their own energy resources to prolong the service time of the network. SPIN protocols are concerned with naming the data with the help of high-level descriptors or meta-data [9]. These protocols decrease unnecessary transferring in the network using meta-data negotiations to reduce redundant transmissions in the network. Hence, a node having some data firstly advertise it by delivering an advertise packet. This packet means that the node has sensed an event or got data from another node. If some other node receives the advertised packet and shows interest in the data then it will transmit a request packet, and after getting the request packet the node will transfer the original data in the data packet.

ii. Directed Diffusion: Directed diffusion is referred to as a data-centric (DC) and application-based algorithm paradigm. In this protocol, the pairs of attribute-value pairs name to all data produced by sensor nodes pairs. The DC approach is concerned with combining the data approaching from different sources enrooted (in-network aggregation) by removing redundancy, lessening the number of transferring. In this way, these protocols save network energy and extend the operating time of WSNs. In contrast to conventional end-to-end routing, DC routing looks for routes from many sources to a single destination that facilitates in-network consolidation of unnecessary data [10].

iii. Rumour Routing (RR): The core idea of the RR (Rumour Routing) algorithm is to fill in the area between the query flood and the event flood. This is useful only if the number of questions is between two interfaces in comparison to the number of occurrences.

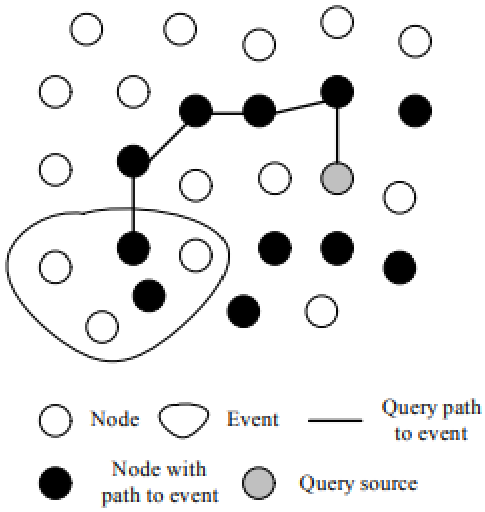

Fig. 1.3.2: Rumour Routing Protocol

In contrast to event flooding which forms a gradient region across the network, the major objective of this protocol is to establish route regarding every episode [11]. Thus, a generated query can be delivered randomly until an event route is obtained rather than flooding it in the entire network. Once the event route is discovered, it can be forwarded directly to the episode. Or else, if it is not possible to find the route, the application can attempt to re-submit the query or flooding it. The Rumour Routing can be suitable to deliver queries to events in large-scale networks in accordance to a broad area of situations (energy needs less than the alternatives). It has been developed to adapt to different application needs, while some adjustments in this protocol can be made to support varying queries for event percentages, successful delivery rates, and route repairs. In addition to this, it can handle node failure elegantly that reduces its delivery rate linearly with the number of dead nodes.

1.3.3. Hierarchical Protocols

The routing protocols in this category enact a design on the network for achieving energy efficiency, stability, and scalability [12]. The protocols in this category arrange network nodes in clusters. In every cluster, the node with more remaining energy is selected to play the role of a CH (Cluster Head). The cluster head coordinates activities within the cluster and forwards information between clusters. Clustering has capability to decrease energy expenditure and prolong the operating time of the network. These protocols have high delivery ratio and scalability and has potential to balance the energy expenditure. Unlike other networks nodes, the nodes beside the base station or CH depletes their energy sources more rapidly. The link failure is an issue that makes certain parts of the network to be inaccessible. If a node connecting a section of the network to the rest network fails, then this section will get disconnect from the rest of the network.

i. Low-energy adaptive clustering hierarchy (LEACH): The LEACH protocol is a very popular hierarchical protocol. In this protocol, almost every node transmits to cluster heads. The working of this protocol can be divided into two phases, namely, set-up phase and state phase as shown in the figure [13]

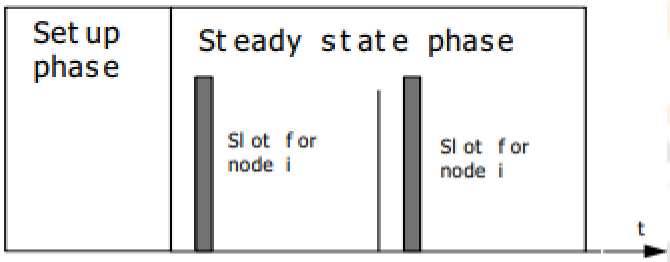

Figure 1.3.3: Running process of LEACH

The set-up phase organizes the clusters and selects the cluster heads. The cluster heads aggregate, summarize and send the data to the sink. Every node uses a stochastic algorithm at each round to assert whether it will turn out to be a cluster head or not, in this round.

$$T(n) = \begin{cases} \dfrac{p}{1-p[i \bmod (\frac{1}{p})]} & n \in G \\ 0 & \text{otherwises} \end{cases}$$

If a node turns out to be a cluster head once, then, it is not possible for this node to be cluster head again for P rounds. Here, P represents the required percentage of cluster heads [14]. Subsequently, the possibility of a node to be a cluster head in evert round is 1/P. This rotation of CHs give rise to balanced energy consumption to all the nodes and hence prolongs the operating time of the network. In the second phase, the data is forwarded to the sink. The period of the steady state phase is lengthier in comparison to the period of the setup phase to make overhead minimum. In addition to this, every node other than the cluster head chooses the nearest cluster head and joins that cluster. Thereafter, the cluster head generates a schedule for all nodes in its cluster to data transmission. The major benefit of LEACH is that performs better that classic communication protocols, with respect to energy consumption, ease of set-up, and lifetime/quality of the network.

The various variants of LEACH protocol have been discussed below:

- LEACH-C: LEACH-C (LEACH-centralized) protocol is considered to be a centralized protocol as sink issues all the decision and then these decisions are delivered to the sensing nodes. Likewise, the sink selects the cluster head of the network and manages the clusters. The main advantage of this protocol is that it distributes the nodes among the clusters in outstanding way.
- LEACH-DCHS: The purpose of the LEACH-Deterministic Cluster Head Selection (LEACH-DCHS) protocol is to extend the service time of the network. Consequently, two amendments have been presented [15]. The first modification is concerned with the adjustment of the threshold equation, which considers the remaining power at the motes to choose the cluster head of the network. The Second Amendment introduces a new description regarding the serving period of the network.
- T-LEACH: The main idea of the Threshold-LEACH (T-LEACH) protocol selects the threshold energy approach-based cluster heads in the network. In addition to this, the cluster heads are employed for finite number of rounds. This condition continues until the residual energy of cluster head goes lower than the threshold energy. A new CH is selected when this incident takes place.
- U-LEACH: The objective of U-LEACH (Unequal Clustering LEACH) protocol is to decrease the exploitation of energy in a one hop transmission, just like the LEACH protocol. The single-hop way is responsible for transmitting the CH data directly to the sink. The earlier scheme increases the expenditure of energy in the cluster head, that are placed distantly from the sink [16]. This is the reason that this protocol assumes that the cluster size will be irregular and less era cording to the distance from the base station.
- LEACH-B: The main reason of designing the Leach-B (Leach-balanced) protocol was to deal with the issue of uneven clusters in the classic Leach protocol. This protocol not only considers the required proportion of the nodes inside the clusters but also the remaining energy in the nodes to select the CH and form a balanced cluster. In this way, this protocol minimizes the broadcast distances across the network.

Conclusion

Wireless Sensor Network is energy that assists in obtaining a longer life span during their execution on finite battery reserves. The main source of power utilization is to transmit the multi-hop packet across the wireless networks. In the Wireless Sensor Networks, the crucial task is that a less energy must be consumed especially in sensor networks that have included the nodes and taken as a lightweight having a finite battery power. Different network architectures including OSI and Internet are basically functional models which are organised as layers at which the services are offered to the layer above through the layer. The quality of the service metrics of network like delay, throughput, availability, reliability and even security can be utilized to compute a network. The CTNR is an energy efficient routing algorithm that has potential for enhancing the duration of WSN. In this research work, the CTNR protocol is enhanced using gateway nodes. In the proposed protocol, the whole network will be divided into clusters using location based clustering. The cluster head will be selected in each cluster based on the distance and energy. The sensor node which has least distance to base station and maximum energy will be selected as the cluster head. The nodes which are unable to be selected as cluster head will be elected as leader nodes based on the energy. In the last, the gateway nodes will be deployed in the network. The sensor nodes transmit information to cluster head which will be later transmitted to leader nodes and leader nodes will transmit information to gateway node. The gateway node will forward information to base station. The proposed model is implemented in MATLAB and results are analyzed in terms of number of alive nodes, dead nodes and number of packets transmitted in the network. It is analyzed from the results that number of dead nodes are reduced, number of alive nodes are increased and number of packet transmitted also increased in proposed technique as compared to existing technique.

Wireless sensor network configuration protocol is crucial for efficient data transmission and resource utilization. Factors such as energy efficiency, scalability and adaptability to different environments should be considered. Protocols like zigbee, Bluetooth low energy and LoRaWAN offer diverse options, each with its own strengths and limitations. Ultimately, the choice should align with specific application requirements to achieve optimal performance in wireless sensor network deployments.

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