AN OVERVIEW OF CLUSTERING PROTOCOLS FOR WIRELESS SENSOR NETWORKS

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Abstract
Researchers have been increasingly drawn to the field of Wireless Sensor Networks (WSN) in recent years. However, a number of challenges remain, including the need to reduce power consumption, optimise routes, increase battery life, and more. One solution has been to use a clustering approach, but selecting a cluster head is a time-consuming process.

Keywords: *Sensor Network, Cluster Head Selection, LEACH, TEEN, APTEEN*

Introduction

The Wireless sensor network, abbreviated as WSN, is best conceptualised as a collection of sensors that, when deployed in a certain sensor field, go to work to keep track of various aspects of the target environment. After measuring each of these factors, the information that was pertinent to the topic was gathered. The WSN is a recently developed technology that has a wide range of potential applications, including the monitoring of environmental factors, the protection of critical infrastructure, industrial sensing, and context-aware computing, among others. All of the communication that takes place in Wireless Sensor Networks (WSNs) happens in a wireless format between the nodes. big regions include a diverse population of users, including a big number of people using mobile devices. Therefore, nodes in wireless sensor networks (WSNs) refer to the towers in a given region that are acting in the capacity of sensors.

As a result, it is possible for data to be sent from one node to another over the medium of air. In this transmission network, a variety of different numbers of nodes are used, and in this network, one node serves as the source, while another node serves as the destination. Any architecture, from simple star networks to advanced multi-hop wireless mesh networks, may be employed in wireless sensor networks. Data transmission, whether it be via the routing of data or flooding, may make use of a variety of different propagation mechanisms.

Different protocols are used in wireless sensor networks for the purpose of selecting the cluster head. There are a significant number of nodes present in WSNs, and each of these nodes have the capabilities of sensing, communicating, and computing. The process of selecting how data will be sent might be referred to as "routing," and it's this process that gives the word its name. Through the use of the external mobile sink, it is possible for any and all of the network's nodes to send and receive data directly with one another. The disadvantages of using a static sink inspired the development of the concept of a mobile sink, which was later put into practise.

By using the mobile sink, the network was able to minimise its overall energy consumption, which resulted in an increase in its effective lifetime. The cluster heads, also known as CHs, are chosen by this process by employing the weight values. In addition to this, the concept of event driven is being put into practise, which will further enhance the lifespan of the network by reducing the amount of energy that is being used.

When it comes to the transmission of data between the sensor nodes and the base station, routing techniques are an absolute need. It is impossible to construct a global addressing scheme for a large number of sensor nodes, which is one of the reasons why routing in WSN is different from routing in traditional IP networks. Another reason is that, unlike regular correspondence systems, all utilisation of sensor systems requires the stream of detected information from a variety of sources to a single BS. Routing in WSN exhibits a number of other distinctive characteristics, such as the fact that it is impractical to build a global addressing scheme. A variety of routing strategies have been suggested for use in remote sensor networks, and these protocols may be categorised according to a variety of criteria. The fact that the base station (BS) is able to acquire information that was previously gathered by neighbouring sensor nodes has a negative impact on the effectiveness of the network. In order to eliminate this data redundancy and to change the network in a manner that is most efficient in terms of energy, a focus has been placed on the aggregation of data and the fusion of sensor information. In order to create the most efficient network possible in terms of energy use, a number of academics have come up with a variety of routing paradigms based on a variety of different principles.

The cluster based routing paradigm is a brilliantly efficient concept that involves the grouping of sensor nodes for the purpose of forming a cluster.One of the heads of each cluster is chosen to be the Cluster head (CH), and this individual is referred to as the CH.

Clustering Protocols

In recent years, there has been a growth in the usage of wireless sensor networks (WSNs), and concurrently, there has been an increase in the challenges connected to energy constraints. This is because there is only a certain quantity of energy that can be stored in the battery. Because the operation of nodes is wholly reliant on the quantity of energy, it is not a simple procedure to recharge or replace the battery unit. If only one of the nodes in the network stops functioning, then the whole network will be rendered inoperable. The architecture of the hierarchical and non-overlapping clusters of sensor nodes is specified by the protocols used for clustering. In order for self-organizing sensor networks to function properly, a reliable clustering method is required. An effective strategy for clustering assures the formation of clusters that have almost the same radius and cluster heads that are positioned in the clusters in the most advantageous way possible. Route discovery among cluster heads is all that is necessary to build a viable route in a network that is clustered. This is due to the fact that each node in a clustered network is linked to a cluster head. When compared to a flat, nonclustered network, a clustered network may simplify the finding of multihop routes and reduce the amount of transmissions. This is especially useful for large sensor networks. This section gives a short explanation to the strategies or protocols for selecting the cluster heads, with regard to the criteria that were employed for selecting the cluster heads. The following is a list of the routing protocols for Wireless Sensor Networks:

a. LEACH
b. PEGASIS
c. TEEN
d. APTEEN

a. LEACH

Which stands for Low-Energy adaptable Clustering Hierarchy, is a method that is both adaptable and capable of autonomously organising itself inside a network. If the cluster head remains fixed throughout the whole of the system's lifespan, then it is likely to be seen that the cluster head will pass away very fast due to the selection of unfortunate sensors, which will result in the cessation of the usable lifetime of nodes included inside such clusters. This method is used in order to generate energy-efficient networks by spreading the load in an even manner among all of the nodes that are included within the network. Within the LEACH paradigm, the transmission of data takes place between the sensor node and the cluster head. The cluster head is the node that first gathers the information from the other nodes that make up the cluster before sending it on to the sink node. After the cluster has been formed, the next step is to choose the cluster head using a probabilistic equation. This step must be completed. After the cluster head has been picked, the following step will begin, and during this stage, the information that has been obtained will be sent to the base station (BS). This stage is also referred to as the steady state stage. The maximum overhead of the whole network will be reduced thanks to the assistance of the second stage. The TDMA method is used throughout the process of transmitting data to the base station; the specifics of this procedure are determined by the cluster head in addition to the total number of member nodes. Large-scale networks cannot support its implementation due to technical limitations. The LEACH protocol has a natural inclination to adjust itself, and it also has a tendency to organise itself in an automated manner. The LEACH protocol ensures that the cluster heads are rotated at regular intervals inside the cluster itself to ensure that the energy is distributed evenly across the cluster. Before beginning the process of implementing the LEACH protocol, two assumptions are made, and they are as follows: 1. The BS is situated some distance away from the nodes, and in addition, the BS is unchanging in its characteristics. 2. Each individual node in the network functions in a manner similar to the others and has a constrained capacity for the quantity of energy it can store.

B. PEGASIS

PEGASIS (Power-Efficient Gathering In Sensor Information System) This method is being put forth as a solution to the problems associated with the collection of information. These are challenges that are encountered by the conventional methods. In this method, data is sent from the sensor node to the base station by first sending the information that has been obtained to the sensor nodes that are geographically the most nearby, and then sending the information that has been processed to the BS. Because the sensor network's nodes all have the same load, we can conclude that this method successfully achieves a uniform distribution of loads among the different nodes in the network. Therefore, the sensor nodes in the network are randomly positioned because they create the chain in the network when data is being sent by the sensor nodes in the network. The calculation of the chain that is constructed is the responsibility of the base station, and thereafter, the information is sent among the sensors that are part of the network. The greedy paradigm is used by this protocol in order to create the chain among the sensor nodes. The chain is constructed on the basis of the information that is held inside the sensor nodes. In comparison to other common protocols like LEACH, the PEGASIS protocol offers far more benefits. The PEGASIS approach has the potential to do away with the overhead of the network when it comes to the formation of dynamic clusters. Because there is no need to build dynamic clusters when using the PEGASIS approach, the count of transmissions is significantly decreased when using it. Because it needs just one transmission from the nodes to the BS in one cycle, it also has the additional benefit of being able to be deployed across large-scale networks. This is another one of the many advantages that are associated with it. The fusion of data is carried out according to this protocol while it is being carried out along the chain, but it is not carried out at the end of the chain. Before beginning the process of putting the PEGASIS protocol into action, the following presumptions are made: Each sensor node in the network stores information on the location of all of the other nodes in the network. All of the sensor nodes in the network are permanently embedded in their respective natural environments.

c. TEEN

Threshold sensitive Energy Efficient Network protocol is an improved form of ordinary LEACH protocol. TEEN protocol was introduced for temperature sensing networks. Major disadvantages of TEEN protocol are: it can be deployed over the large scale network containing large number of sensor nodes, large amount of energy is consumed, and the clusters formed by this protocol are unbalanced in nature. Reason behind the unbalanced cluster is that the CHs are randomly selected. By implementing TEEN protocol there is no increment in the lifespan of the wireless sensor networks as the cluster heads are not selected on the basis of residual energy of nodes. Drawbacks of TEEN are as below

- It elects the CH randomly before the occurring of an event in the network. It allows the sensor nodes to establish communication out of the region which leads to the excess energy consumption and unbalanced clustering in a network.
- It comprised of single hop communication among CH and BS.

D. APTEEN

LEACH serves as the foundation for the development of the Adaptive Threshold-sensitive Energy Efficient Network protocol, with CH serving as the variable that is chosen at random. It will produce random numbers ranging from 0 to 1 throughout the process of cluster formation and then compare those numbers to a threshold denoted by T(n). Should the produced value be more than the threshold, the node will be converted into a CH for the current round. Where p represents the elected probability of the MCHs among all of the nodes, r represents the number of the current round, and G represents the groupings of nodes that have not yet been picked as MCH nodes during any of the previous 1/p rounds. Once the CH has been identified, it will announce that it has been chosen to serve as the CH for this round and will broadcast the attribute, the hard threshold (HT), the soft threshold (ST), and the count time (CT) parameters. Each node has the potential to collect messages from one or more MCH, and it will choose the cluster that has the strongest received signal as the one in which it will participate. After the establishment of the cluster, CM will begin its continual sensing. Once the value reaches or surpasses HT, the sensed value (SV) is written into an internal variable, and the data is then sent to CH in accordance with the TDMA schedule that has been allocated to it. And after that, the CM node continues to sense. Only in the event that the perceived value is more than HT and, at the same time, the variations of sensed value in both the transmitter and the receiver are greater than ST will the sensed value be stored and broadcast once again. In addition, when CT is exceeded, the sensed value does not exceed the threshold value, which results in the absence of sensed data. This results in the nodes being compelled to provide data to CH. CT refers to the longest possible gap in time that exists between two reports that were progressively sent by a node. Because data transmission seems to occur on a periodic basis, the sensed values of nodes are sent to CH on a regular basis. Reducing the amount of energy used by the network may be accomplished by careful selection of threshold values and CT.

A reactive network protocol known as APTEEN (Adaptive periodic threshold sensitive energy efficient sensor network protocol) is an adaptive periodic threshold sensitive energy efficient sensor network protocol. Hybrid Networks integrate the beneficial aspects of proactive and reactive networks while minimising the negatives of each of both types of networks. In a network like this one, nodes send data at regular intervals but at comparatively longer intervals than usual, and they also send data when the detected value goes beyond the threshold they've set for themselves. As a result, the energy from the sensors is utilised in an extremely effective manner by decreasing the number of transfers of data that is not essential. The user has the ability to alter the periodicity, the threshold value(s), and the parameter that is to be sensed in the various zones. By making the appropriate adjustments to the network's periodicity and threshold settings, it is possible for this network to simulate either the proactive or the reactive network. Because of flexibility, it is possible to utilise this network for any kind of application by appropriately configuring the different parameters. Nevertheless, the greater level of complexity at the sensor is a direct result of this flexibility and adaptability. In this paper, the adaptive periodic threshold-sensitive energy efficient sensor network protocol known as APTEEN (Adaptive Periodic Threshold-sensitive Energy Efficient sensor Network Protocol) is presented as a novel protocol for hybrid networks. There are certain applications in which the user not only wants to collect time-sensitive data, but also wants to query the network in order to analyse situations that aren't related to collecting time-sensitive data. In other words, the user could want a network that responds rapidly to time-critical circumstances and provides an overall picture of the network at frequent intervals in order for the network to be able to answer analytical questions. Due to the inherent constraints of any sensor network, none of the aforementioned options is capable of properly performing both tasks. It is possible for APTEEN to develop a new form of network known as a hybrid network by combining the beneficial aspects of reactive as well as proactive networks while simultaneously minimising the drawbacks of each. The nodes that make up this network not only communicate data at regular intervals, but they also react to unexpected shifts in the values of the attributes they track. In this manner, the protocol may function both as an anticipatory protocol and a reactive protocol. The TEEN protocols serve as a basis for this, and the following modifications are made to it. The following activities will be carried out throughout each cluster period in APTEEN once the CHs have been determined. Following is the parameter that is first transmitted by the CH.

Thresholds: This parameter consists of a HT and a ST. HT is a value of an attribute beyond which a node can be triggered to transmit data. ST is a small change in the value of an attribute that can trigger a node to transmit. Schedule: This is a TDMA schedule, assigning a slot to each node. Count time: This is the maximum time period between two successive reports sent by a node. It can be a multiple of the TDMA schedule length, and it introduces the proactive component in the protocol. Data values exceeding the threshold value are referred to as critical data. The nodes sense their environment continuously. However, only those nodes that sense a data value at or beyond the hard threshold transmit. The exception to this rule is that if a node does not send data for a time period equal to the count time, it is forced to sense and transmit the data, irrespective to the sensed value of the attribute. Hence, a TDMA schedule is used and each node in the cluster is assigned a transmitter slot. The main features of the scheme are as follow: 1) By sending periodic data, it gives the user a complete picture of the network, like a proactive scheme. It also senses data continuously and response immediately to drastic changes, making itresponsive to time critical situations. Thus it behaves as a reactive network. 2) It offers a lot of flexibility by allowing the users to set the count time interval and the threshold values for the attributes. 3) Changing the count time as well as the threshold values can control energy consumption and can support proactive and reactive behavior in a sensor network.

As the demand on the node rises, there is a greater chance that another query may come before the node has finished transmitting the previous query. It is very improbable that a sensor network that includes energy.In this scenario, limited nodes will be forced to function in an environment in which there will either be the same number of inquiries as there are nodes at any one moment, or a single node will be queried several times during the span of one frame time, which is equivalent to around a fraction of a second. Even if the query frequency is higher than the frame time, several nodes will still get the inquiry that is broadcast by the user. Therefore, the system has sufficient redundancy to deal with loads of this kind. However, in the event that the worst should happen, we would want to make the system as resilient as is humanly feasible so that it is able to deal with scenarios that include significant loads. When new queries come in while older ones are still being processed, we utilise the buffer that is available at each node to temporarily store them. The queries are dequeued in accordance with the first-come, first-served (FCFS) model.

Hence, the frame size is also expected to vary according to a normal distribution. We initially considered a fixed frame size to simplify the model. To start with, we consider a situation where all nodes form only one cluster and hence, the frame-size is a constant and is given by Frame Time = no. of sleep nodes * sleep slot + no. of idle nodes * idle slot + (CH -> BS) slot + (BS -> nodes) slot.

Described above is mainly based on hierarchical routing protocol which relevant to applications and difficulty of wireless sensor, the protocol is difficult to say which is more superior. Based on the performance requirements above, here the comparison of the routing protocols described in the text shown in Table 1.

Table 1: Comparison of Routing Protocols

	LEACH	PEAGSIS	TEEN	APTEEN
Energy Conservation	Very Good	Very Good	Very Good	Very Good
Network Life Time	Good	Very Good	Very Good	Better
Data Based	No	Yes	Yes	Yes
Location Based	No	No	No	No
Robustness	Better	Better	Better	Better
Scalability	Good	Good	Good	Good
Security	No	No	No	No

The TEEN protocol send the value of sensed parameter to the base station, when there is sudden and significant change in the threshold value of that parameter higher than or equal to the set threshold, then sensor node switch on its transmitter to send the required information to the base station. APTEEN is the enhance version of TEEN protocol, it send the sensed periodical data at regular time interval and it can be used in both application either proactive or reactive. APTEEN has a disadvantage over TEEN that it consumes more energy than TEEN because it sends the sensed data periodically. This protocol have four parameters i.e.- hard threshold, soft threshold, current value and the count time.

APTEEN has one more parameter than the TEEN which is count time. Count time is a counter which is a time duration after which the node sends the sensed value to the CH whether it reaches the threshold or not. In this way it gives the solution for real time applications but at the cost of more energy dissipation [1] . It is observed that it is one of the hierarchical clustering protocol in which hierarchy of sensor nodes is present. In this protocol data is accumulated from sensor nodes and transmitted from cluster head of first level to cluster head of next level and so on until it reaches to the Base station. TEEN executes its function on the basis of a threshold value. It is an enhancement of TEEN protocol in order to overcome its drawbacks. It uses the same concept of TEEN to reduce energy dissipation. This protocol provides a time critical information as well as constant transmission of sensed data to user. It works on the combination rule from both the LEACH and TEEN protocol. Its efficiency is between the two protocols as it performs the function of both the protocol [2]. In this protocol, nodes sense the medium continuously, but the data transmission is done less frequently. The network consists of simple nodes, first-level cluster heads and second-level cluster heads. TEEN uses LEACH’s strategy to form cluster. First level CHs are formed away from the BS and second level cluster heads are formed near to the BS. It allows the user to set threshold values and also a count time interval. If a node does not send data for a time period equal to the count time, it is forced to sense and retransmit the data thus maintaining energy consumption. Since it is a hybrid protocol, it can emulate a proactive network or a reactive network depending on the count time and threshold value.

It has the disadvantage that additional complexity is required to implement the threshold function and count time features [5]. It is a basic routing protocol of hierarchical clustered multihop routing protocol. TEEN protocol in WSN assume a trusted environment where all sensor nodes cooperate each other without any attacks. There are routing protocol groups based on their mode of functioning and the type of target application in WSNs: proactive and reactive routing protocols. In proactive routing protocol, once the cluster heads

(CHs) are decided after cluster exchanging, the CH node creates a TDMA schedule and assigns each node a time slot when it can transmit. After setup phase, cluster members sense the phenomena and transmit the data to the CH. The CH aggregates this data and sends aggregated data to the higher level CH, or the BS depends on the network hierarchy. Low-Energy Adaptive Clustering Hierarchy (LEACH) is a good example of a proactive routing protocol with some small differences.

TEEN protocol: node-to-CH, CHto-BS, and CH-to-CH communication [8]. The LEACH and PEGASIS protocols hold up applications where information from sensor nodes is rarely transmitted to the sink. Therefore, the information pleased from multiple nodes is decreased throughout aggregation method. Though, these protocols may not be reactive to event-based applications, where information is generated only when assured events take place. The TEEN protocol aims to give event-based release in the network. APTEEN protocol is the addition protocol of the TEEN protocol, which correct the parameters issued through the cluster head, which can change associated parameters according to the requests of users, together with a set of physical attributes uttered that users expect to get; hard and soft threshold; operation mode (TDMA); counting time (CT), the mainly time period represented successful data communication of a node. APTEEN moreover used superior TDMA scheduling thus allocating a specific slot for transmission for preventing data redundancies [12]. TEEN is based on a hierarchical grouping where closer nodes form clusters and this process goes on the second level until the BS (sink) is reached. TEEN is a clustering communication protocol that targets a reactive network and enables CHs to impose a constraint on when the sensor should report their sensed data. After clusters are formed, the CH broadcasts two thresholds to the nodes namely Hard threshold (HT), and Soft threshold (ST). The architecture of APTEEN is same as in TEEN, which uses the concept hierarchical clustering for energy efficient communication between source sensors and the sink. APTEEN guarantees lower energy dissipation and helps in ensuring a large number of sensors alive. When the base station forms the clusters, the CHs broadcasts the attributes, the hard and soft threshold values, and TDMA transmission schedule to all nodes, and a maximum time interval between two successive reports sent to a sensor, called count time (TC) [15]. In modified APTEEN, focus is on increasing the energy efficiency of the sensor network by modifying the cluster head selection in APTEEN. New clusters are formed and cluster head are selected by using the random number generation system in clustering. However, during the simulation of the environment in APTEEN, it is observed that with the passage of time nodes starts to be dead because of power shortage [18]. The "APTEEN" is an expansion of "TEEN" and goals at both taking episodic data gatherings and replying to time-critical

Conclusion

In order to pick cluster heads in a wireless sensor network in an effective manner while using less energy, clustering routing techniques are an absolute need. This article offers a two-headed cluster presentation.In wireless sensor networks (WSN), an Adaptive Threshold-sensitive Energy Efficient Network based on an Ant Colony (ADCAPTEEN) and a Multiple Adaptive Threshold-sensitive Energy Efficient Network based on an Ant Colony (AMAPTEEN) have been proposed as potential solutions.The conventional T(n) is modified by two different suggested protocols, and MCH and CH are chosen after taking the residual energy of the nodes into account. Making a decision between MCH and CH is the most sensible option. By forming multipaths with the help of ant colonies, AMAPTEEN lowers the amount of energy used, increases the number of nodes that survive, and lengthens the life cycle of the network.

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