A Survey on Data Aggregation Protocols for Wireless Sensor Networks

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ABSTRACT:- Wireless Sensor Networks (WSN) has several sensor nodes which sense different parameters and it sends to the same base station. The sensor node has very limited battery power that is used for sensing, computing, and communication. Elimination of redundant sensed data and aggregation of nearest sensor values is necessary in order to minimize the path of the node and send it to the other node without any energy loss. Hence to conserve the battery power and by enhance the lifetime of a WSN, we require energy efficient data aggregation algorithms. Our main objective is to differentiate and deals with the study of data representation model in data aggregation protocols based on energy conservation model using networks based systems and algorithms. And also it deals about the various data aggregation network based protocols in the aspects of various factor such as Aggregation Method, Scalability, Resilience in case of Energy saving method and Timing strategy.

Keywords: WSN, Data aggregation, Sensor node

1. INTRODUCTION:

A wireless Sensor Network (WSN) is a highly distributed network composed of sensor nodes with special capabilities, and they are deployed in large-scale area to monitor the environment and collect related information. It have wide applications in a broad spectrum of areas including military, environment and medical systems.WSNs have variety of applications like video surveillance, automation of industry, connected smart homes, controlling and monitoring of air traffic and medical equipment, robot control, monitoring atmospheric weather conditions and much more which may be critical to life safety and risk management. The WSNs may be used in a variety of everyday life activities or services. For example a common application of WSNs is for monitoring.In the area of monitoring, the WSN is deployed over a region in order to monitor some phenomenon. A practical use of such a network could be a military use of sensors to detect enemy intrusion. In case that the sensors detect an event (change on heat or on the blood pressure) then the event is immediately reported to the base station, which decides the appropriate action (send a message on the internet or to a satellite)[10]. A similar area of use may be the monitoring of the air pollution, where the WSNs are deployed in several cities to monitor the concentration of dangerous gases for citizens. Moreover, a WSN may be used for forest fires detection to control when a fire has started. The nodes will be equippedwith sensors to control temperature, humidity and gases which are producedby fire in the trees or vegetation.

In sensor networks,it consists of collection of sensor nodes and it havelimited battery energy.Once it is deployed in the field,it is not possible to recharge or replenish the node battery.In this process ,we need some energy efficient data gathering and processing mechanisms to enhance the network life time.For efficient process, it can be done by using some of the data aggregation methods. Data aggregation has been put forward as an essential paradigm for wireless routing in sensor networks. The idea is to combine the data coming from different sources enroute – eliminating redundancy, minimizing the number of transmissions and thus saving energy. This paradigm shifts the focus from the traditional address-centric approaches for networking (finding short routes between pairs of addressable end- nodes) to a more data-centric approach (finding routes from multiple sources to a single destination that allows in-network consolidation of redundant data)[11].

1.1 Data Aggregation:

Data aggregation is a process of aggregating the sensor data using aggregation approaches.It is defined as gathering and aggregating the sensed data to get the meaningful information. It is a fundamental processing method to save energy and effective way for saving the limited resources.The algorithm uses the sensor data from the sensor node and then aggregates the data by using some aggregation algorithms such as centralized approach, LEACH (low energy adaptive clustering hierarchy), TAG(Tiny Aggregation) etc.The data will be transfer to the sink node by choosing the efficient path.

In data aggregation, the data iscollected by the sensor node is given to the aggregation algorithm .Then it eliminates the redundancy and hence reduces the size of the data to be communicated to the sink node.

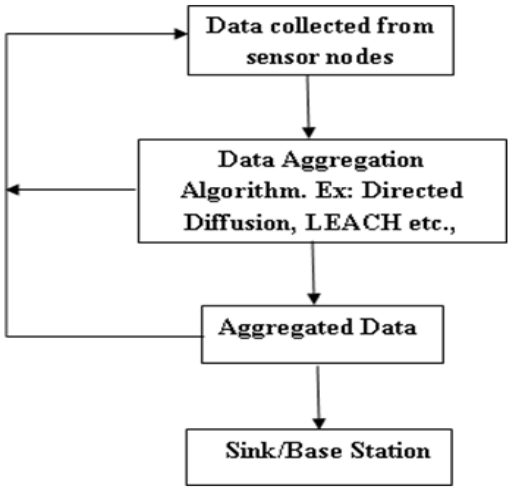


Fig 1: Data aggregation System

From above diagram, it represents the important stages in the data aggregation.In data aggregation, there are many types of aggregation techniques, some of them are : CentralizedApproach,In-Network Aggregation, Tree-Based Approach and Cluster based Approach.

1.1.1 Data Aggregation Architecture

2. DATA AGGREGATION NETWORKS:

2.1 Flat Network

In this network type, the data centric routing is used for the data aggregation. .In data centric routing the sink node transmits query message to the sensor nodes via flooding or other broadcasting techniqures. .The sensor nodes which have the data matching with the query message send reply back to the sink node [12].

2.2 Hierarchical Networks

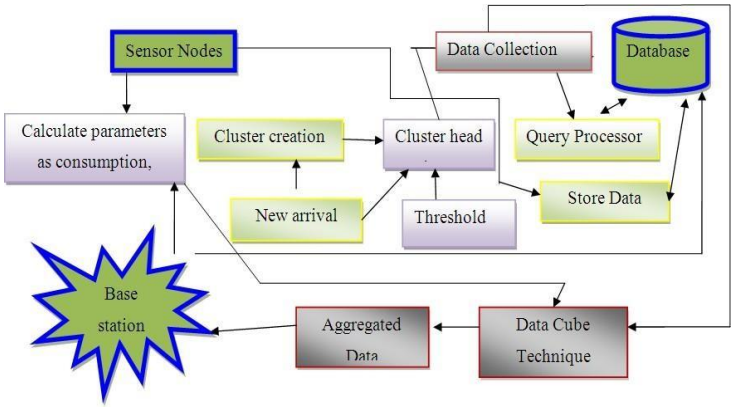
In this network type, the data aggregation will be performed by the special nodes and the aggregated data is sent to the sink node. The special nodes reduce the data communicated to the sink by the use of aggregation technique. This results in the reduction of energy consumption.As a result network life time is increased [13].

Difference between Flat and Hierarchical Networks based on the parameters:

There are some paramters for comparing the both networks, such as Data aggregation, fault tolerance, Overhead, latency, routing, Node heterogeneity.

3. ENERGY EFFICIENT ROUTING PROTOCOLS:

Routing protocols are very important phase in supporting the Data Aggregation process. The objective of the data aggregation is to lessen the energy consumption. In accord to promote the network aggregation, the sensor nodes should track the packets based on content of the data packets and also select the next hop.Since there is no specific infrastructure in WSNs, the sensor node should meet the energy saving requirements. Routing protocols developed in WSN for energy efficient is tabulated based on some categories.



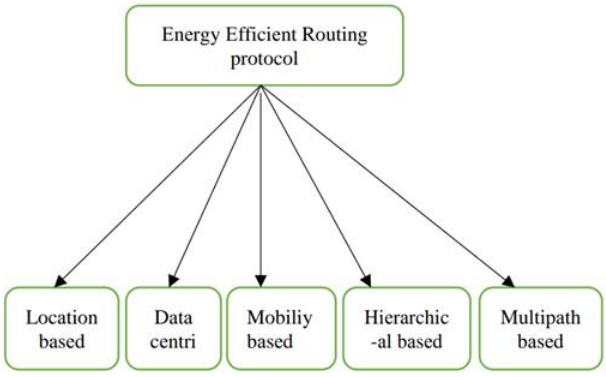


Fig 3 : Protocols

3.1 Location based Protocols:

The sensor nodes are covered by their locations is known as location based protocols. The distance between two nodes in a sensor networks is estimated for its location information. When minimum energy is deployed, the maintenance cost is increased simultaneously.To efficiently utilize the energy at low cost, a segment in data link acquires Automatic Repeat Request (ARQ) protocol is utilized [14].

3.2 Data Centric Protocols:

A data centric protocol is varied from the Address centric protocols. A sink node forwards the queries to the specific regions and searches the data in that specific region from the sensors. Each data queries are represented by attribute based naming strategy. The energy maximization is done by restricting the resources. The smallest distance between the two nodes is a straight line [14].

3.3 Mobility based Protocols:

In mobility based protocols,the node which possesses less mobility is selected as the cluster head which leadsto more stable clusters.It can be also known as energy-unware routing protocols.The sink mobility is an efficient way to eliminate this issue and extend the lifetime of a network by lessening the communication overhead which is close to the sink.

3.4 Multipath based Protocols:

In multipath based protocol, it eliminates the action which the data packets are forwarded to the sink node directly form the sensor node.And it also eliminates the action which the sensor nodes consumes more battery.In multipath routing protocols produces less scalability and simplicity. Some multipath routing eliminates the topology exposure protocols

3.5 Hierarchical Routing Protocols:

The hierarchical routing protocol is the most energy efficient protocols in WSN because of its higher energy conservation.The hierarchical protocols are used to find the shortest path for addressing scheme.In hierarchical routing protocol ,it is in the form of chain based protocols which minizes the energy consumption level because each node communicates with the next close-by- neighbour and then transmites to the base station.It transfers in the optimal path and the sensor nodes are arranged in the clustering based schemes to maximize the life span of the network. . The issues such as congestion control, node collision and resource blindness solved in cross layer fashion.The initial determination such as receiver based contention, initiative based forwarding, local congestion control and distributive cyclic operation to adopt a reliable communication .The multiaxis division based approach is introduced to overcome the threshold problem and eliminate the sink dependency. The data aggregation approach handles a variety of queries. The Poisson Arrival Rate is estimated to handle the heavy loads using Time Division Multiple Access (TDMA).

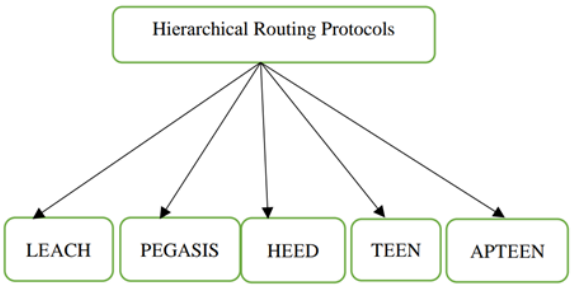


Fig 4: Hierachical Routing Protocols

3.5.1 Low Energy Adaptive Clustering Hierarchy (LEACH):

LEACH is a TDMA based Mac protocol which is integrated with clustering and simple routing protocol in WSN.The main aim of LEACH is to lower energy consumption require to create and maintain clusters in order to improve the life time of WSN. In LEACH each node uses a STOCHASTIC algorithm at each round to determine whether it will become a cluster Head.

It performs local data fusion to “compress the amount of data among sent from the clusters to the base station.

The LEACH network has two phases: The set-up phase and The steady-state. LEACH protocol refers to Low Energy Adaptive Clustering Hierarchy [8], which is designed as a routing protocol for Wireless Sensor Network. Generally speaking, there are three steps in cluster routing protocol: the generation of cluster heads, the formation of clusters and the communication among clusters. Hence, LEACH algorithm also includes these three steps, just merging the first two steps into one that is the establishment of clusters and the communication among clusters[1].

As for the cluster head, it always maintains communication status to receive the data from the nodes in its cluster at any time. Once received all data from its member nodes, then the cluster head will process the data such as data fusion to lower down the redundant data. Finally, the cluster head transmits the fused data to its own cluster head or the base node; as for non-cluster nodes, they send the data in its own time gap and during the other time, they turn off their wireless communication module to conserve energy[2].

Advantages and Disadvantages of LEACH Protocol:

LEACH protocol adopts the method that selects cluster heads at random, which avoids the cluster head to be premature death due to the excessive consumption of

energy and form the phenomenon of monitoring blind area. Besides, data fusion efficiently reduces the amount of data communication. Hence, compared with the general routing protocols and static routing protocols, LEACH protocol can prolong the lifetime of Wireless Sensor Network about 15%[2].

3.5.2 PEGASIS:

PEGASIS is the improved protocol where only one node is choses a head node which sends the fused data to the BS per round.It performs better than the LEACH.This achieves factor of 2 improvement compared to LEACH protocol.Improvements are Chain based protocol and each node communicates only with a close neighbor.The steps of PEGASIS are Chain construction and Gathering of data.Edified by the idea of the traditional ant colony algorithm, we propose a routing protocol-PEG-ant using an improved ant colony algorithm to construct the chain of PEGASIS. In the building process, to choose a node as the next one on the chain, we make all of the current node's neighbors as candidates and take factors such as the remained energy of the candidate, the amount of consumed energy if we transmit unit data along the branch between the current node and the candidate, and also the quantity of pheromone on the branch as selection standard[4].

Strictly speaking, PEGASIS is not a hierarchical protocol, but it follows the same basic idea. At the beginning, following the greedy algorithm, all of the sensor nodes are organized to form a chain. All the work is done by the base station (BS). Starting from the furthest node, it chooses each node's closest neighbor as the next one on the chain. Once the chain has been constructed, in each round of communication, one node will be chosen as the leader. Along this chain, in the direction of the leader, each node fuses the received data with its own to transmit to the other neighbor. The process goes on until data reaches the leader. Then, the leader transmits the final fused data to the BS [5].

3.5.3 Hybrid Energy Efficient Distributed (HEED):

Heed is designed to select different cluster heads in a field according to the amount of energy distributed in relation to neighbouring node. The BS may transfer with the additional sensor nodes. HEED (Hybrid Energy Efficient Distributed) protocol is an energy effectual clustering protocol. It generally uses remaining energy as principal factor, node degree and distance to neighbors as next factors. It prolongs the uncomplicated structure of LEACH protocol. The clustering method is separated into a number of steps and in every single step, sensor nodes which are not enclosed by any cluster; it generally doubles the possibility of becoming a cluster head (CH)[7].

A general HEED protocol. Here the CH is designated by some portion of remaining energy to supreme energy influenced by the nodes. Direct communiqué takings place and unalike energy smoothed systems have been generated. Dissimilar levels of non- uniformity are generally used. In two levels H-HEED, two categories of nodes advanced nodes and normal nodes are used. In 3 levels H2018 5th International Conference on Signal Processing and Integrated Networks (SPIN), three categories of nodes super, advanced and normal nodes are used. In this non-uniform methodology all the sensor nodes are having dissimilar energy level [6].

Four primary goals of Heed:

- Prolonging Network life time by distributing energy consumption.
- Minimizing control over heads
- Producing well distributed cluster heads.
- Terminating unwanted iterations.

3.5.4 Threshold sensitive Energy Efficient sensor Network (TEEN):

TEEN depends on group based various leveded approach and uses information driven strategy.TEEN is occusion driven,receptive protocol which is most appropriate for time basic application.It transmit information in hard threshold and soft threshold values as it uses information driven methodology in which information is essential and asked for in view of quantity worth. The working of TEEN is : Hard threshold (HT): This is a limit esteem for the detected characteristic.It is the total estimation of the property past which the node detecting this quality must switch on its transmitter and report its cluster head. Soft threshold(ST): This is a little change in the estimation of the detected properly which triggers the node to switch on its transmitter and transmit.

TEEN(Threshold-sensitive Energy Efficient sensor Network protocol)[8] is a typical response routing protocol. Comparing with active routing protocols, response routing protocol will transmit packet when the observation variable mutates. Therefore, response routing protocol is more suitable for time-sensitive WSNs. The core idea of TEEN protocol is that the cluster head is chosen periodically, probability and randomly. The other node joins the cluster just because the cluster head is nearest to it. This can reduce the energy consumption and

prolong the network lifetime. In the phase of clustering, cluster head broadcast its hard threshold and so00ft threshold within the cluster. TEEN keeps the balance between network energy consumption and data transmission precision by hard threshold and soft threshold adjustment. Each cycle of TEEN is divided into two stages: the clustering phase and the data transmission phase.

3.5.5 Adaptive Periodic Threshold sensitive Energy Efficient sensor Network(APTEEN):

In APTEEN, the node senses the environment continuously only that nodes which senses the data value are sent beyond the hard threshold transmit.When a node senses a value beyond Hard threshold,it then transmits the data when the attribute value changes by an amount equal to or greater than Soft threshold. It has four parameters with it, there are attributes, threshold, schedule, count time.

Attributes: This is a set of physical parameters which the user is interested in obtaining data.

Thresholds: This parameter consists of a Hard Threshold(HT) and a Soft Threshold(ST).

Schedule: This is a TDMA schedule, assigning a slot to each node.

Count Time: It is the maximum time period between tow successive reports sent by a node.[9]

Features of APTEEN:

- It has both proactive and reactive policies.
- It allows the user to set the count time interval
- Count time value and threshold value can be changed or controlled so that energy consumption can be obtain.

Fig 5.Merits and Demerits of Hierarchical Protocols

Protocols	Merits	Demerits
LEACH	Load balancing is efficient. Collision is prevented.	Fit to small regions. Energy is not utilized for selection of cluster head that Leads to overhead.
Power Efficient Gathering in Sensor Information System (PEGASIS)	dynamic cluster formation. Data transmission rate is low. Balanced node formation.	Data Processing is delayed.
Hybrid Energy Efficient Distributed (HEED)	Distributed Clustering method. CH is uniform. Maximized energy conservation. Support long range communications	Inappropriate energy consumption. Cause overhead in cluster head selection. Expired soon due to overload.
Threshold sensitive Energy Efficient sensor Network Protocol (TEEN)	Energy consumption is reduced by the use of thresholds. to reactive scenes.	Periodic reports are not generated. Data loss.
Adaptive Threshold sensitive Energy Efficient sensor Network protocol (APTEEN)	Applicable to proactive and reactive applications. Controlled energy consumption	Design complexity is large in supporting multi-path.

4. SUMMARY OF THE BASIC CHARACTERISTICS OF DATA AGGREGATION PROTOCOLS

Although these protocols promise the energy efficiency, further research is required to address issues such as quality of service in real-time applications. The applications include real time military applications, event triggering in precision agriculture etc. require energy-aware QoS routing. This will guarantee the bandwidth of connection as well as provides the energy efficient path. The mobility of a node requires more number of updates in terms of its position, and propagation of that information to other nodes may consume more energy. The battery of the nodes may drain out fast. To handle this situation and overhead of the mobility, new routing protocols need to be designed in an energy constrained environment.

5. CONCLUSION:

Data aggregation in sensor networks has attracted a lot of attention in the recent time. In this paper, we summarized recent research results on data aggregation and routing in WSN.We surveyed routing protocols by taking into account several classification criteria, including location

information, network layering and in-network processing, data centricity, Mobility-based, Multipath- based Protocols, network heterogeneity, and QoS requirements. If we consider the parameters Aggregation Method, Resilience to Link Failure, Setup Overhead, Scalability, Resilience in case of node mobility, Energy saving method, and Timing strategy, the Cluster based data aggregation protocols perform well compared with other protocols and we can build energy efficient WSN with these protocols.

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