A Review on Distributed and Centralized Protocols in Wireless Sensor Networks

Ancy Varghese, M Tech Student, Anna University, Chennai, ancy.varghese@saintgits.org
Ojus Thomas Lee, Associate Professor in CSE, College of Engineering Kidangoor, ojusthomaslee@gmail.com

ABSTRACT - Wireless sensor networks (WSNs) are a network of many typically small sensor nodes. These WSN have huge application in habitat monitoring, disaster management, security and military, etc in locations which are restricted or inaccessible to human users. Wireless sensor nodes are very small in size and have limited processing capability with very low battery power. This restriction of low battery power makes the sensor network prone to failure. Protocols which are Power aware, support Data aggregation, has distributed mechanism for constructing topologies may be effective technique in this context . In this paper an attempt is made to review four protocols (LEACH, PEGASIS, PEDAP and L-PEDAP) in WSN with discussion on their variants.

Keywords - Data Aggregation, Distributed topology creation, Energy efficient, LMST, L-PEDAP, RNG, Wireless Sensor Networks

1. INTRODUCTION

Wireless Sensor Networks are used to collect information from a large environment, where physical situations are so harsh so that conventional sensors cannot be used .Wireless Sensor Network play a vital role in situations such as battle field, desert and forest area to monitor real world physical parameters such as pressure, temperature, vibration, humidity, sound, motion, light intensity, flow rate etc.

Wireless sensor networks (WSNs) consist of sensor nodes and one or more base station (BS) or sink. Sensor nodes are of limited processing capability and low power battery. A sensing element and a transceiver are part of the sensor node. The environment is sensed by the sensor nodes and data in the form of signals is send to the base station. The sensor nodes are usually scattered in a sensor field. Each of these scattered sensor nodes has the capabilities to collect data and route data back to the sink. Data are routed back to the sink by a multi hop infrastructure less architecture through the sink. The sensor nodes consume energy while sending and receiving data. Sensor nodes have less amount of energy so energy conservation is the important factor in sensor network. Generally, the radio transmission range of the sensor nodes are the orders of magnitude smaller than the geographical extent of the entire network. Therefore, data should be
transmitted towards the sink node hop-by-hop in a multi-hop manner. By reducing the amount of data which requires to be transmitted, the energy consumption of the network can also be reduced.

Data aggregation is the good technique to save the precious energy of sensor nodes. Usually in a sensor network thousand of sensor nodes are deployed for area monitoring. Most of them sense the environment and send the data to the base station. The base station combines all the information for the desired output. If we can aggregate the data in intermediate nodes in the multi hop route before reaching the base station we can potentially decrease the number of packets in the network. So we will have to send less number of packets to base station that can save the energy of sensor nodes. These types of data aggregation are called In-Network data aggregation[12] where packets are combined before reaching the base station. We can define the data aggregation as follows, Data aggregation techniques explore how the data is to be routed in the network as well as the processing method that are applied on the packets received by a Node. They have a great impact on the energy consumption of nodes and thus on Network efficiency by reducing number of transmission or length of packet. The in-network aggregation process as follows: "In-network aggregation is the global process of gathering and routing information through a multi-hop network, processing data at intermediate nodes with the objective of reducing resource consumption (in particular energy), thereby increasing network lifetime."

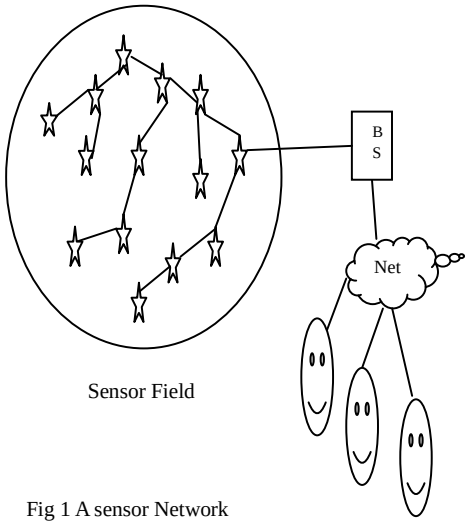

Fig 1 A sensor Network

Since, a large number of nodes are distributed in a large monitoring area, individual nodes are often correlated in the network. The end user does not require all the data, some of them are redundant, data generated in the sensor network may be too much for the end user to process. So functions for combining data into a small set of useful information is required. A practical way of doing that is aggregating (min, max, sum,

count, average) the data originating from different nodes in the correlated area.

Wireless sensor network can assume different topologies in which data aggregation can be implemented. These can be i) Cluster based as can be seen in LEACH[1] and its variants ii) Chain structure as in PEGASIS[5] iii) Tree structure as in PEDAP[6] and its variants.

2.COMPARISON OF PROTOCOLS IN WIRELESS SENSOR NETWORKS

2.1 LEACH(Low Energy Adaptive Clustering Hierarchy)

LEACH[1] protocol is a clustering protocol .Clusters is grouping of the neighbouring sensor nodes. Each cluster will have lead node called cluster head. The cluster head will be responsible for collecting data from the cluster and communicate to the base station. The nodes in the cluster save energy since they send data to the cluster head only and hence their life time is increased. A LEACH based WSN is shown in fig2.

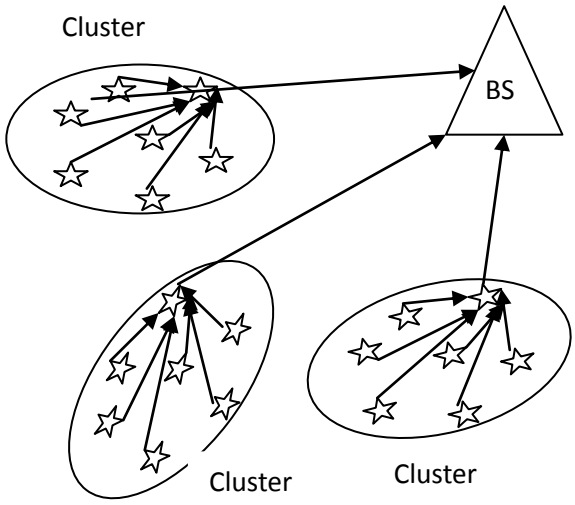

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Fig 2 LEACH based WSN

LEACH protocol runs with many rounds. Each round contains two states: 1) cluster setup state and 2) steady state. In cluster setup state, it forms cluster in self-adaptive mode; in steady state, it transfers data. The time of second state is usually longer than the time of first state for saving the protocol payload.

Cluster setup phase consists of i) Advertisement phase ii) Cluster Setup phase iii)Schedule Creation Phase .In advertisement phase each node decides as to be a cluster head or not by comparing the random number generated in the node with a threshold value calculated which is global for all nodes. The number of cluster heads required is decided in apriori. Once the cluster heads are decided they broadcast an advertisement signal. Based on the power of the signal received nodes decides their own cluster heads .In Cluster Setup phase each node (after deciding which is their cluster head) communicate back to their respective cluster heads to actually form the cluster. Schedule Creation phase a TDMA schedule is created by the cluster head for the nodes in the cluster and informs each node when to respond.

In steady state phase the nodes send data to the cluster heads according to the schedule and the cluster heads does the aggregation and sends it to the base station.

The communication from cluster heads to the BS was one of the major drawbacks with the LEACH protocol. Each cluster head transmit the data directly to the Base Station. This make the cluster heads to spend more power for transmission and hence the reduced life time.

2.2 Variants of LEACH

2.2.1 E-LEACH (Energy LEACH)

E-LEACH[2] is energy aware version of LEACH. In E- LEACH the selection of the cluster head is based also on the knowledge of the currently available energy of each node which try to become a cluster head. This ensures improvement in the life time of the network.

2.2.2 TL-LEACH (Two Level LEACH)

TL-LEACH[3] tries to make an improvement to LEACH by reducing the transmission distance of the cluster head by making the transmission in two level. Far cluster heads instead of sending data directly to the base station ,it is send to the nearest cluster head which is more closer to the base station. Thus TL-LEACH try to improve the network life time.

2.3 CTPEDCA (Cluster and Tree based Power Efficient Data Collection and Aggregation Method)

CTPEDCA[4] is another improvement to the LEACH protocol. In this protocol the network form clusters as in the case of normal LEACH protocol. The CTPEDCA runs through i) cluster head formation ii) cluster formation iii) Tree formation of cluster heads iv) Transmission Phase. The cluster head election also happens in the same way. The improvement is that cluster heads communicate to the base station by forming a tree amongst them using Minimum Spanning Tree.

2.4 PEGASIS (Power Efficient Gathering in Sensor Information Systems)

The cluster based methods has a disadvantage that if the cluster heads are far from the nodes it will result in more energy consumption by the nodes and hence lesser life time of the nodes. The solution to this lies in a node sending the data to its nearest node only, which is the basic underlying concept of PEGASIS[5].

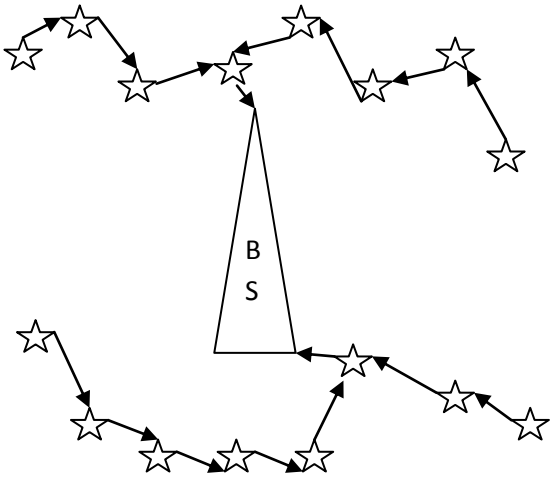

Fig 3 A chain based WSN

PEGASIS first forms a linear chain of nodes themselves using a greedy algorithm or sink can determine the chain in a centralised manner and broadcast it to all sensor nodes. The chain formation will be initiated from the farthest node. Once the chains are formed, the data gathering phase starts. In this a node receives data from its neighbour, fuses the received data with its own and sends it to the next neighbour in the chain. A leader node is selected in random that will send the fused data to the base station. The leader node will change after a stipulated number of rounds, to ensure balanced energy spending among leader nodes. We can use a control token initiated by the leader to enable data send from the both sides.

2.5 PEDAP (Power Efficient Data Gathering and Aggregation Protocol)

Chain based protocols have problem in the length of chains, and it is difficult to find whether the chain is long or optimal. Longer chains will result in delay and also more energy spend.

PEDAP[6] is tree based protocol which works in a centralised manner using the Prim's algorithm[9].It works in 2 phases. In the phase I the MST (Minimum Spanning Tree) is constructed with the BS as the root. In phase II the data from each of the nodes are send through the MST to the base station. After a stipulated number of rounds the MST is recalculated to adjust for nodes which are dead.

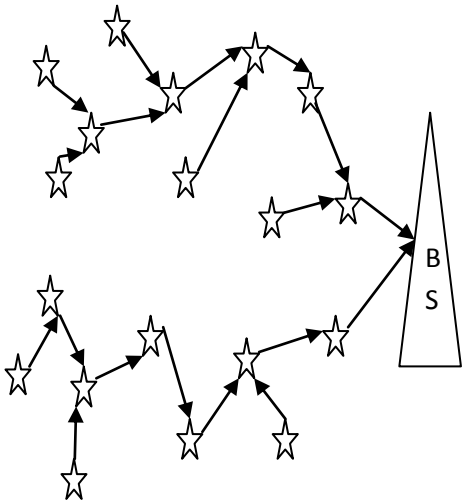

Fig 4 A tree based WSN

PEDAP-PA[10] is a power aware version of the PEDAP which keeps track of the energy of each node and for those nodes which are very low in energy, the cost of sending data to the base station is set to very high. This will make the node not to be a competitor in the tree in the next round.

2.6 L-PEDAP(Localised PEDAP)

The centralised nature of the PEADP itself is a problem. The energy consumed for sending and receiving the topology recalculation after stipulated amount of time is very high.

In L-PEDAP[7] the basic idea is to reduce the extra energy spend in communicating the topology to the nodes. This is done by recalculating the topology locally by the sensor nodes. For localising the topology calculation LMST(Localised MST)[10] or RNG(Relative Neighbourhood Graph)[11] methods are used.

L-PEDAP runs in two phases. In the first phase a sparse topology over the visibility neighbourhood of each node is calculated using the LMST or RNG .These structures are super sets of MST and easily calculated locally.

LMST is computed as follows. First, each node determines its one-hop neighbours and computes an MST for that set of nodes, based on the distance between nodes as the weight of the edges. After computing the MST of the neighbours, each node i selects the edges (eij) where node j is a direct neighbour of node i in its MST. The resulting structure is a directed graph. The structure can be converted to an undirected

one in two ways . First way is to include edge (eij) only when both nodes i and j include that edge (LMST_). The second way is to include that edge when either node i or node j includes it ($LMST_+$).

RNG can be generated as follows. An edge eij is included in the euclidean RNG graph if there are no nodes closer to both nodes i and j than the distance between nodes i and j. That is, an edge eij remains in RNG if it does not have the largest cost in any triangle ikj for all common neighbors k. The euclidean MST of a graph is a subgraph of its RNG.

In the second phase using the locally constructed topologies are used to create the LMST structure for the whole of the network. First Parent Method(FP) or Minimum Hop(MH) method or Shortest weighted Path (SWP) Method will be used for the construction of the structure. The structure created in the second phase will be used for the data transmission to the base station.

3.Comparison of Data Aggregation Protocols

In this paper we compare the above mentioned protocols. Table 1 represents the comparison. It is based on the study in ref[8] and modified accordingly.

Table 1 Comparison of Protocols

Protocol	**Data Aggregation**	**Power Aware**	**Distributed or Centralised**	**Category**
LEACH	Yes	No	Distributed	Clustering
E-LEACH	Yes	Yes	Distributed	Clustering
TL-LEACH	Yes	Yes	Distributed	Clustering
CTPEDCA	Yes	No	Distributed	Clustering and Tree
PEDAP	Yes	No	Centralised	Tree based
PEDAP–PA	Yes	Yes	Centralised	Tree based
L-PEDAP	Yes	No	Distributed	Tree based

4.CONCLUSION

Sensor Networks hold a lot of promise in applications where gathering sensing information in remote locations is required. It is an evolving field, which offers scope for a lot of research.Designing an efficient protocol for the wireless sensor network that is suitable for all applications is quite tedious task. But it is very important to make attempts to meet this condition. A study and comparison of the existing main protocols based on centralized and distributed environment has been presented. This study will help to gather knowledge on the working of the major data aggregation protocols .

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