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Survey on Wireless Sensor Networks-Structure & Routing Protocols

Rajesh L.[1*] and Mohan H. S.[2]
[1]Research Scholar, SJBIT, Bangalore, Karnataka, India. Email: raj.nimmava@gmail.com; rajeshyl2001@yahoo.co.in
[2]Professor & Head, Dept. of ISE, SJBIT, Bangalore, Karnataka, India. Email: mohan_kit@yahoo.com
*Corresponding Author

Abstract: Wireless Sensor Networks (WSN) are large collection of tiny nodes in order to gather information or to monitor the surrounding. The network formed with these set of nodes are organized into various manner. In order to provide a guaranteed service a periodic data collection of the environment is required and hence WSNs required to maximize network lifetime. The efficiency of WSN is strongly depends on routing protocols & other parameters like aggregation techniques, security. Variety of sensing capabilities results, sensor network usage in wide applications with most effective methods for data transmissions & processing.

Keywords: CH, Clusters, Routing protocols, Sensors, WSN.

I. Introduction

Wireless sensor networks are a collection of large number of small sensor nodes, specifically configured to communication infrastructure with limited storage capacity, computational resources & sensing range. These sensor nodes respond / communicate each other via radio within a specified boundary for i) Measuring the environment for different parameters like temperature, pressure, humidity, moisture, acid, light, gas, concentration of chemicals, body parameters etc... ii) Recording or monitoring the locations and machinery remotely.

A sensor network is a collection of sensor nodes with limited power and hence the lifetime of nodes is less. In order to increase the lifetime of entire sensor network, the energy consumed for various activities of sensor nodes should be reduced. It is not a good idea to keep redundant data transmission within the environment. Therefore, the key factor in WSN design is by the way in which each node senses & transmits data to base station.

Better security protocol is to be designed to make sure that the data gathered from a set of nodes to be secure until it reaches base station.

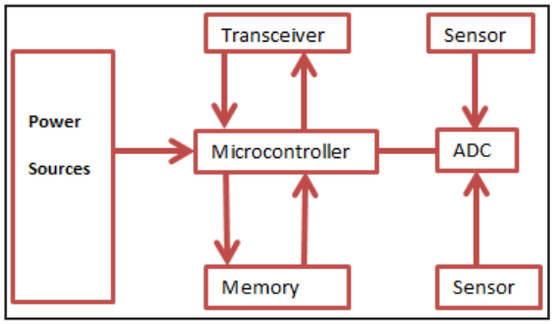

Fig. 1: Architecture of Sensor Node

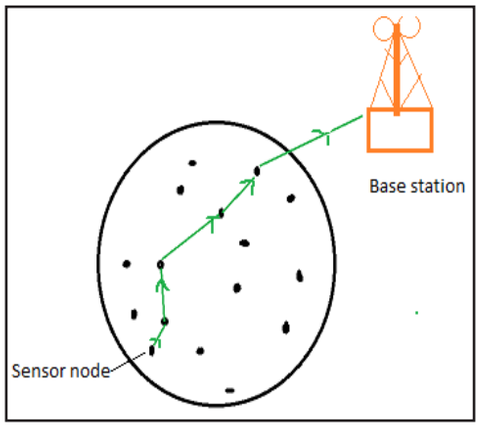

Fig. 2: Working of Sensor Node in WSN

Applications of sensor networks can be in monitoring [machinery, habitat, agriculture, industry, battlefield, and tsunami etc.] and controlling.

II. Background of Data Collection and Transmission

Data sensed by each of the sensor node in the deployed area is to be transmitted to Base Station to take necessary decision.

The data sensed at different intervals of time may be same or different. It's a good idea to transmit the data if any difference in the observation else no need to establish a data transmission to its neighbours or to the Base Station. Thereby, it will reduce resources, bandwidth utilization and hence avoids congestion.

A better way of handling redundancies in the sensed data is by choosing aggregate function. So aggregation at different levels helps in reducing multiple transmissions between sensor nodes and Base Station. This can be done in a prominent method called In-Network data processing & aggregation.

Sensor networks can be classified based on the structure as follows:

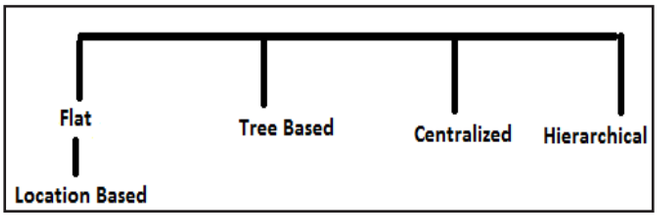

Fig. 3: Classification of Sensor Networks

A. Flat Networks

Each node plays same role in this network. According to the structure of wireless sensor network, if Base Station is reachable from a sensor node then direct transmission of data happens else via nearest node data transmits. Therefore, it uses data centric approach. There is high latency and poor security.

Flat networks use algorithms like DAG, SPT, Ant colony algorithm, etc.

DAG [Directed Acyclic Graph]: In DAG [10] each node to have multiple parent nodes as intermediate nodes which provide tolerance for the failure in transmission. Drawback of this algorithm is each parent is keeps on adding its own data & causes redundancies.

Ant Colony Algorithm: This algorithm [12] simulates the real ant's behaviour, which helps in finding the shortest path between food sources and their home places. In WSN nodes finds routes and communicates with other to build shortest paths using pheromones; collection of pheromones forms the aggregation tree. In Ants colon algorithm delay is more and traffic load get increase as the chain increases with more aggregators.

Multipath Data Aggregation Approach: Data aggregation is performed at every intermediate node between source and destination. If the path fails to transmit data to sink / destination, the alternate paths is used & ensure delivery of data [15][16].

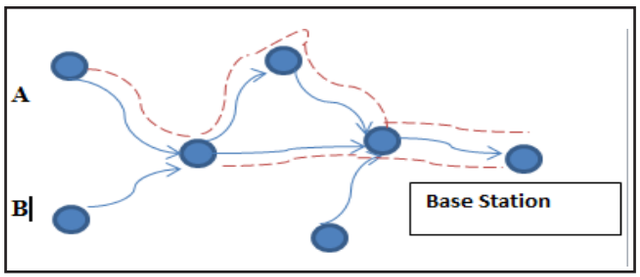

Fig. 4: Multipath Data Aggregation Approach

Rumour Routing: It is an adaptive algorithm [1][9][13], it works with query flooding and event based flooding by using direct diffusion method; where the interested neighbours reply to a query packet by re-requesting for the data packet. This process will repeat until the specific node is reached.

B. Centralized Approach

In this approach irrespective of nodes placement or presence, all nodes are to be transmitted to central node and which intern transmits to Base Station.

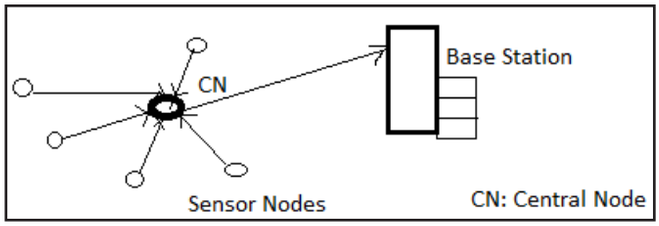

Fig. 5: Centralized Architecture

Centralized node is called header node, with much more computational capabilities as compared to other nodes in the network.

Centre at Nearest Source Algorithm: CNS algorithm [4] is used for collecting the nodes data from its nearest neighbours through SPT and then aggregates at intermediate level. Further, this aggregated data is transmitted to destination or Base station.

C. Tree Based Networks

This structure should be preferably manual, where each intermediate node is called as parent for its sensor nodes & hence the aggregation of data happens at this level. Later the intermediate nodes forward data to its ancestor till it reaches to sink node. Therefore, data aggregation is performed by constructing aggregation tree minimum spanning tree. Drawbacks of this structure are data loss happens when intermediate node fails for any reason.

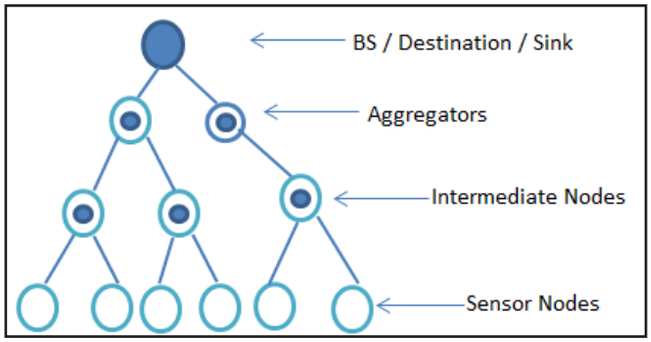

Fig. 6: Tree Based Network

Tiny Aggregation Service Algorithm: In TAG algorithm [6][15] has dynamic parents; that is parent nodes can be switchable. Parents send notification to their children about waiting time for collecting data. But TAG needs considerable message transmission to construct tree.

Greedy Incremental Tree Algorithm: GAT [4] is used for tree based approaches. And it establishes path between source & destination by adding nearest neighbour to the established path acyclically.

D. Hierarchical Networks

The sensor deployed areas are first formed into clusters where each clusters have been elected with Cluster Head (CH). The data sensed by these members of the cluster are forwarded to CH in TDMA slots to avoid clashes. The CH combines all these data based on timestamp & the aggregated information is forwarded to base station or to its nearest CH.

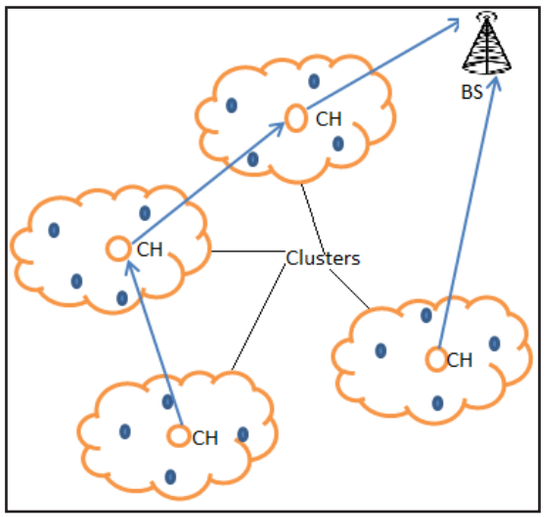

Fig. 7: Hierarchical Structure

Therefore, hierarchical network with clusters minimize power consumption & increase network lifetime. There are many algorithms used in hierarchical networks:

LEACH: Low energy adaptive cluster hierarchy [1] is a cluster based scheme, where Cluster formation and cluster head selection are the two phases in it; Clusters formed within certain range of coverage in hierarchical structure. Cluster head is selected probabilistic, election, residual energy or volunteer or random basis. Within that range the nodes should communicate to CH.

TEEN: Threshold sensitive energy efficient sensor network [2] is a cluster based approach which follows LEACH protocol. Where authors presented message transmission consumes more energy rather for sensing. It is more suitable for reactive networks.

PEGASIS: Power efficient gathering sensor information systems [3] is a chain based power efficient routing protocol. It is a reactive protocol for homogenous sensor nodes. Here based on the signal strength the neighbours are found & then adjusted. Then nodes passes tokens through the chain formed, soon after the chain is used for data transmission.

INFRA: Information fusion-based role assignment algorithm [11] is used to build a cluster for each event sensed by the nodes. The similar event sensed nodes transfer their data to CH; CH merges these data & sends to sink.

Once the cluster & CH's formed, the CH uses SPT [4] to build shortest path towards sink. Limitations of INFRA are duplication of packet of every event & communication cost.

DRINA: Data routing in-network aggregation is a cluster based algorithm, which builds routing infrastructure by maximizing the aggregation points in routing tree, this tree is created by selecting the nodes in shortest path. It selects cluster of same event sensed nodes & does not floods a message to whole network.

III. Performance Evaluation

In this section we have done comparative analysis of network structure and algorithms used in each structure by using following parameters.

i) *Energy Consumption*: Energy is consumed for various activities of sensors, due to limited energy it requires more attention in performing data collection, processing, aggregating, and transmission activities.

ii) *Packet Delivery Rate*: It is the rate of delivery of packets from source to destination. That is how many number of packets successfully delivered to the destination.

iii) *Redundancy:* Rather than sending same information / data again and again, will consumes lot of energy and wastage of resources. Therefore, redundancy should be overcome.

iv) *Delay:* Delay is incurred if the numbers of communication (or control) messages are more. Also delay becomes more, if more number of nodes connected with heterogeneous bandwidth.

v) *Accuracy:* It is essential that sensor data should be accurate and free from errors even after the transmissions. It is possible by providing better security mechanisms in terms of confidentiality, integrity, and authenticity so that no intruder / hacker / fraudulent can damage the data.

IV. Comparative Study of Network Structure

Network Structure	Technique	Redundancy	Delay	Accuracy	Energy Consumption
TREE	DBST	Less	Moderate	Moderate	Less
	DEAD	Moderate	Less	Moderate	Moderate
	SDRE	Less	Less	High	Less
CLUSTER	LEACH	Less	Less	High	Very Less
	TEEN	Moderate	More	Moderate	More
	APTEEN	Moderate	More	Moderate	Moderate
	PEGASIS	Less	More	Moderate	Less
	BHCDA	Less	Moderate	Less	Less
	REDD	Less	Less	Moderate	Less
	EERDAT	Moderate	Less	High	Less
	EEBCDA	Less	Less	High	Less
FLAT	SPIN	Moderate	Moderate	More	More
	RR	More	More	Moderate	More
CENTRALIZED	CNS	Moderate	More	Less	More

V. Conclusion

This paper provides brief description about various design issues, protocols used in different wireless sensor network structures. The functionalities and performance of each protocol is discussed. We found some interesting parameters wherein energy consumption and accuracy will characterize these networks.

Data aggregation and routing plays a major role in minimizing the energy consumption. So, depending upon the application suitable network structure and protocols can be used.

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