

Wireless Sensor Network: A Review on Data Aggregation

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Abstract— Data aggregation is very crucial techniques in wireless sensor network. Because with the help of data aggregation we reduce the energy consumption by eliminating redundancy. When wireless sensor network deployed in remote areas or hostile environment. In the wireless sensor network have the most challenging task is a life time so with help of data aggregation we can enhance the lifetime of the network .In this paper we discuss the data aggregation approaches based on the routing protocols, the algorithm in the wireless sensor network. And also discuss the advantages and disadvantages or various performance measures of the data aggregation in the network.

Index Terms— Wireless sensor network, data aggregation, architecture, Network Lifetime, Routing, Tree, Cluster, Base Station.

1 INTRODUCTION

THE wireless sensor network is ad-hoc network. It consists small light weighted wireless nodes called sensor nodes, deployed in physical or environmental condition. And it measured physical parameters such as sound, pressure, temperature, and humidity. These sensor nodes deployed in large or thousand numbers and collaborate to form an ad hoc network capable of reporting to data collection sink (base station). Wireless sensor network have various applications like habitat monitoring, building monitoring, health monitoring, military survival lance and target tracking. However wireless sensor network is a resource constraint if we talk about energy, computation, memory and limited communication capabilities. All sensor nodes in the wireless sensor network are interact with each other or by intermediate sensor nodes.

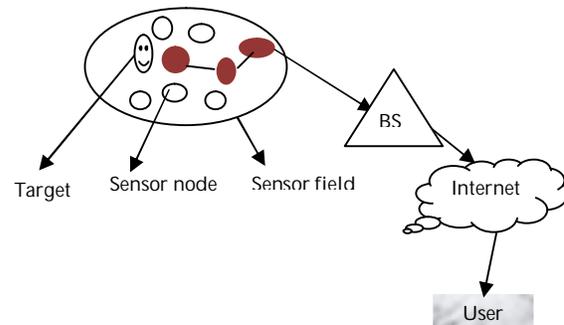


Figure 1 Architecture of the Sensor network

A sensor nodes that generates data, based on its sensing mechanisms observation and transmit sensed data packet to the base station

(sink). This process basically direct transmission since the base station may located very far away from sensor nodes needs.

More energy to transmit data over long distances so that a better technique is to have fewer nodes send data to the base station. These nodes called aggregator nodes and processes called data aggregation in wireless sensor network.

2. CLUSTERING IN WSN

Sensor node are densely deployed in wireless sensor network that means physical environment would produce very similar data in close by sensor node and transmitting such type of data is more or less redundant. So all these facts encourage using some kind of grouping of sensor nodes such that group of sensor node can be combined or compress data together and transmit only compact data. This can reduce localized traffic in individual group and also reduce global data. This grouping process of sensor nodes in a densely deployed large scale sensor node is

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known as clustering. The way of combining data and compress data belonging to a single cluster called data fusion (aggregation).

Issues of clustering in wireless sensor network:-

1. How many sensor nodes should be taken in a single cluster. Selection procedure of cluster head in an individual cluster.

2. Heterogeneity in a network, it means user can put some power full nodes, in term of energy in the network which can behave like cluster head and simple node in a cluster work as a cluster member only.

Many protocols and algorithm have been proposed which deal with each individual issue.

3. DATA AGGREGATION

In typical wireless sensor networks, sensor nodes are usually resource-constrained and battery-limited. In order to save resources and energy, data must be aggregated to avoid overwhelming amounts of traffic in the network. There has been extensive work on data aggregation schemes in sensor networks, The aim of data aggregation is that eliminates redundant data transmission and enhances the lifetime of energy in wireless sensor network. Data aggregation is the process of one or several sensors then collects the detection result from other sensor. The collected data must be processed by sensor to reduce transmission

burden before they are transmitted to the base station or sink. The wireless sensor network has consisted three types of nodes. Simple regular sensor nodes, aggregator node and querier. Regular sensor nodes sense data packet from the environment and send to the aggregator nodes basically these aggregator nodes collect data from multiple sensor nodes of the network, aggregates the data packet using a some aggregation function like sum, average, count, max min and then sends aggregates result to upper aggregator node or the querier node who generate the query.

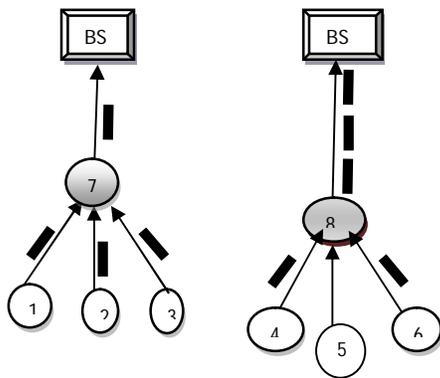


Figure 2 Data aggregation model and Non data aggregation model

It can be the base station or sometimes an external user who has permission to interact with the network. Data transmission between sensor nodes, aggregators and the querier consumes lot of energy in wireless sensor network. Figure 2 contain two models one is data aggregation model and second is non data aggregation model in which sensor nodes 1, 2, 3,4,5,6 are regular nodes that collecting data packet and reporting them back to the upper nodes where sensor nodes 7,8 are aggregators that perform sensing and aggregating at the same time. In this aggregation model 4 data packet travelled within the network and only one data packet is transmitted to the base station (sink). And other non data aggregation model also 4 data packet travelled within the network and all data packets are sent to the base station (sink), means we can say that with the help of data aggregation process we decrease the number of data

packet transmission. And also save energy of the sensor node in the wireless sensor network. With the help of data aggregation we enhance the lifetime of wireless sensor network. Sink have a data packet with energy efficient manner with minimum data latency. So data latency is very important in many applications of wireless sensor network such as environment monitoring, health, monitoring, where the freshness of data is also an important factor. It is critical to develop energy-efficient data-aggregation algorithms so that network lifetime is enhanced. There are several factors which determine the energy efficiency of a sensor network, such as network architecture, the data-aggregation mechanism, and the underlying routing protocol. Wireless sensor network has distributed processing of sensor node data. Data aggregation is the technique. It describes the processing method that is applied on the data received by a sensor node as well as data is to be routed in the entire network. In which reduce energy consumption of the sensor nodes and also reduce the number of transmissions or length of the data packet. Elena Fosolo et al in [5] describe "In network aggregation is the exclusive process of collecting and routing information through a multi hop network. Processing of data packet with the help of intermediate sensor nodes. The objective of this approach is increasing the life time of the network and also reduces resource consumption. There are two type of approach for in network aggregation. With size reduction and without size reduction. In network aggregation with size reduction. It is the process in which combine and compressing the data received by a sensor node from its neighbors in order to reduce the length of data packet to be

sent towards the base station. Example, in some circumstance a node receives two data packets which have a correlated data. In this condition it is useless to send both data packets. Then we apply a function like MAX, AVG, and MIN and again send single data packet to base station. With help of this approach we reduce the number of bit transmitted in the network and also save a lot of energy. In network aggregation without size reduction is defined in the process of data packets received by different neighbors in to a single data packet but without processing the value of data. This process also reduces energy consumption or increase life time of the network.

3.1 Advantage and Disadvantage of Data aggregation in wireless sensor network

Advantage: With the help of data aggregation process we can enhance the robustness and accuracy of information which is obtained by entire network, certain redundancy exists in the data collected from sensor nodes thus data fusion processing is needed to reduce the redundant information. Another advantage is those reduces the traffic load and conserve energy of the sensors. **Disadvantage:** The cluster head means data aggregator nodes send fuse these data to the base station .this cluster head or aggregator node may be attacked by malicious attacker. If a cluster head is compromised, then the base station (sink) cannot be ensure the correctness of the aggregate data that has been send to it. Another drawback is existing systems are several copies of the aggregate result may be sent to the base station (sink) by uncompromised nodes .It increase the power consumed at these nodes.

3.2 Performance measure of data aggregation

There are very important performance measures of data fusion algorithm. These performances are highly dependent on the desired application.

Energy Efficiency: By the data-aggregation scheme, we can increase the functionality of the wireless sensor network. In which every sensor nodes should have spent the same amount of energy in every data gathering round. A data-aggregation scheme is energy efficient if it maximizes the functionality of the network. Network lifetime, data accuracy, and latency are some of the significant performance measures of data-aggregation algorithms. The definitions of these measures are highly dependent on the desired application.

Network lifetime: The network lifetime is defining the number of data fusion rounds. Till the specified percentage of the total nodes dies and the percentage depend on the application .If we talk about some application, simultaneously working of the all the sensor nodes is crucial hence the lifetime of the network is number of round until the first nodes which improves the energy efficiency of nodes and enhance the lifetime of whole network.

Latency: Latency is evaluate data of time delay experiences by system, means data send by sensor nodes and received by base station(sink).basically delay involved in data transmission, routing and data aggregation.

Communication overhead: It evaluates the communication complexity of the network fusion algorithm.

Data accuracy: It is a evaluate of ratio of total number of reading received at the base station (sink) to the total number of generated. There are different types data-aggregation protocols like network architecture based data-aggregation protocols, network-flow-based data-aggregation protocols and quality of service (QoS)-aware data-aggregation protocols designed to guarantee QOS metrics. Here network architecture based protocols are described in detail.

3.3 Impact of data aggregation in wireless sensor network

In this paper we discuss the two main factors that affect the performance of data aggregation methods in wireless sensor network, Such as energy saving and delay. Data aggregation is the process, in which aggregating the data packet coming from the different sources; the number of transmission is reduced. With the help of this process we can save the energy in the network. Delay is the latency connected with aggregation data from closer sources may have to held back at intermediate nodes in order to combine them with data from source that are farther away. Basically aggregation method based on the position of the sources in the network, number of sources and the network topology. If the examine the factors, we consider the two models of the source placement. The event radius (ER) model and random source model [14]. The modelling says us that where the source are clustered near each other or located randomly, significant energy gains are possible with data aggregation. These gains are greatest when the number of sources is large, and when the sources are located relatively close to each other and far from base station. The modelling through, also seems to the suggest that aggregation latency could be non negligible.

4. DATA AGGREGATION APPROACHES IN WIRELESS SENSOR NETWORK

Data aggregation process is performed by specific routing protocol. Our aim is aggregating data to minimize the energy consumption. So sensor nodes should route packets based on the data packet content and choose the next hop in order to promote in network aggregation. Basically routing protocol is divided by the network structure, that's why routing protocols is based on the considered approaches.

4.1 Tree-Based Approach

The tree based approach is defining aggregation from constructing an aggregation tree. The form of tree is minimum spanning tree, sink node consider as a root and source node consider as a leaves. Information flowing of data start from leaves node up to root means sink(base station).Disadvantage of this approach, as we know like wireless sensor network are not free from failure .in case of data packet loss at any level of tree, the data will be lost not only for single level but for whole related sub tree as well. This approach is suitable for designing optimal aggregation techniques'. Madden et al. in [6] data centric protocol know as Tiny aggregation (TAG) approach. The working of TAG is depending on two phases: distributed phase and collection phase.

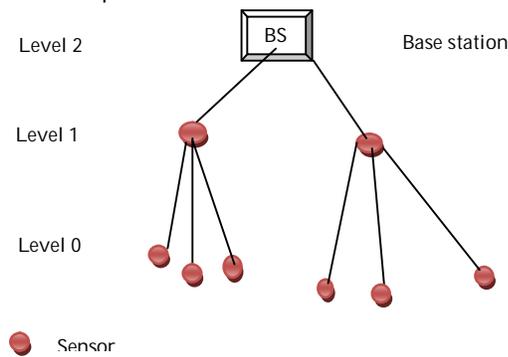


Figure 3 Tree based data aggregation in wireless sensor network

4.2 Cluster-Based Approach

In energy-constrained sensor networks of large size, it is inefficient for sensors to transmit the data directly to the sink. In such scenarios, Cluster based approach is hierarchical approach. In cluster-based approach, whole network is divided in to several clusters. Each cluster has a cluster-head which is selected among cluster members. Cluster-heads do the role of aggregator which aggregate data received from cluster members locally and then transmit the result to base station (sink). Recently, several cluster-based network organization and data-aggregation protocols have been proposed for the wireless sensor network. Figure 4 shows a cluster-based sensor network organization. The cluster heads can communicate with the sink directly via long range transmissions or multi hopping through other cluster heads.

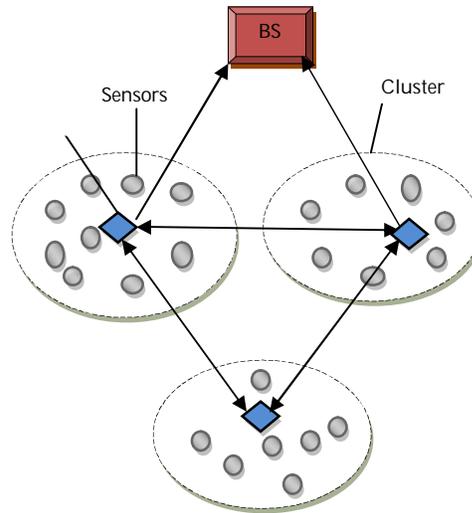


Figure 4 Cluster based sensor network. The arrows indicate wireless communication links

K. Dasgupta et al. in [7] proposed a maximum lifetime data aggregation (MLDA) algorithm which finds data gathering schedule provided location of sensors node and base-station, data packet size, and energy of each sensor node. A data gathering schedule specifies how data packet are collected from sensors node and transmitted to base station for each round. A schedule can be thought of as a collection of aggregation trees. In [4], they proposed heuristic-greedy clustering-based MLDA based on MLDA algorithm. In this they partitioned the network in to cluster and referred each cluster as super-sensor. They then compute maximum lifetime schedule for the super-sensors and then use this schedule to construct aggregation trees for the sensors. W. Choi et al. in [1] present a two-phase clustering (TPC) scheme. Phase I of this scheme creates clusters with a cluster-head and each node within that cluster form a direct connects with cluster-head. Phase I the cluster-head rotation is localized and is done based on the remaining energy level of the sensor nodes which minimize time variance of sensors and this lead to energy saving from unnecessary cluster-head rotation. In phase II, each node within the cluster searches for a neighbor closer than cluster-head which is called data relay point and setup up a data relay link. Now the sensor nodes within a cluster either use direct link or data relay link to send their data to cluster head which is an energy efficient scheme. The data relay point aggregates data at forwarding time to another data relay point or cluster-head. In case of high network density, TPC phase II will setup unnecessary data relay link between neighbors as closely deployed sensor will sense same data and this lead to a waste of energy.

4.3 Multi-path Approach

The drawback of tree based approach is the limited robustness of the system. To overcome this drawback, a new approach was proposed by many researchers .in which sending partially aggregated data to single parent node in aggregation tree, a node could send data over multiple paths. In which each and every node can send data packets to its possibly multiple neighbours. Hence data packet flow from source node to the sink node along multiple path, lot of intermediate node between source node to sink node so aggregation done in every intermediate node. Using this approach we will make the system robust but some extra overhead. The example of this approach like ring topology, where network is divided in to concentric circle with defining level levels according to hop distance from sink.[3]propose a new strategy have both issues : energy efficiency and robustness. In which single path to connect each node to the base station it is energy saving but high risk of link failure. But on the other head multipath approach would require more nodes to participate with consequent waste of energy. Authors present a clever use of multi-path only when there is loss of packet which is implemented by smart caching of data at sensor nodes. Authors also argue that in many practical situation data may be gathered only from a particular region, so they use a different approach that relies on a spanning tree and provides alternative paths only when a malfunctioning is detected. Algorithm adopts a tree-based approach for forwarding packets through the network. In the ideal situation when no failures occur, this is certainly the best choice, as the minimum number of nodes is engaged in the transmission phase. In the presence of link or node failures, the algorithm will discover alternative paths, so as ensure the delivery of as many packets as possible within the time constraints. The problem with this approach is that it may cause the arising of hot spots and nodes along preferred paths will consume their energy resources quickly, possibly causing disconnection in the network.

4.4 Hybrid Approach

Hybrid approach followed between tree, cluster based and multipath scheme. In which the data aggregation structure can adjusted according to specific network situation and to some performance statistics.

Table 1
 Routing protocol for Tree, cluster, Multipath and Hybrid approach.

Protocols/algorithms	Tree	Cluster	Multipath	Hybrid
TAG	✓	-	-	-

Directed Diffusion	✓	-	-	-
PEGASIS	✓	-	-	-
DB-MAC	✓	-	-	-
EADAT	✓	-	-	-
LEACH	-	✓	-	-
Cougar	-	✓	-	-
Synopsis	-	-	✓	-
Diffusion	-	-	✓	-
Tributaries and Deltas	-	-	-	✓

5. DATA AGGREGATION FUNCTION IN WIRELESS SENSOR NETWORK.

Many effective type of data aggregation function is needed in wireless sensor network. These functions are closely related to sensor network application. Such as mean quantile, medium, count, average, max, and min.

5.1 Duplicate sensitive and duplicate insensitive

Aggregation function may be average and minimum. If we use average function , it take as a duplicate sensitive and minimum function is take as duplicate insensitive function in wireless sensor network. Data aggregated in the network on that time same data consider multiple times. We can used duplicate function then the final result depends on the number of the times and same value has been considered otherwise aggregation function is said to be duplicate insensitive.

5.2 Lossy and lossless

Data packet can be aggregated with the help of lossy aggregation or by lossless aggregation. Lossy aggregation approach does not follow a perfect reconstruction but lossless aggregation ensures a complete recovery of all individual sensor data at base station (sink) [2].

6. DATA REPRESENTATION IN WIRELESS SENSOR NETWORK.

Data representation is the effective way to representation the data. Wireless sensor network is consisting a large number of small sensor nodes. These are resource constraint, due to limited resource constraint it needs to decide whether to store, compress, discard and transmit

data. All this requirement wants a suitable way to represent the information any type of structure are common to all sensor node in the network.[14]

7. SECURITY ISSUES IN DATA AGGREGATION FOR WIRELESS SENSOR NETWORK

There are two type of securities are require for data aggregation in wireless sensor network, confidentiality and integrity. The basic security issue is data confidentiality, it is protecting the sensitive data transmission and passive attacks, like eavesdropping. If we talk about hostile environment so data confidentiality is mainly used because wireless channel is vulnerable to eavesdropping by cryptography method. The complicated encryption and decryption operations such as modular multiplication. The

8. CONCLUSION

In this paper we present wireless sensor network is consist a large number of sensor node. And these nodes are resource constraint. That's why lifetime of the network is limited so the various approaches or protocol has been proposed for increasing the lifetime of the wireless sensor network. In this paper we discuss the data aggregation are one of the important techniques for enhancing the life time of the network. And

security issues is data integrity with the help of integrity we reduce the compromised sensor source nodes or aggregator nodes from significantly altering the final aggregation value. Sensor node in a sensor network is easily to compromised. Compromised nodes have a capability to modify or discard messages. Method of secure data aggregation: There are two type of method for securing data hop by hop encryption and end to end encryption, both methods follows some step.

1. Encryption process has to be done by sensing nodes in wireless sensor network.
2. Decryption process has to be done by aggregator nodes.
3. After that aggregator nodes aggregates the result and then encrypt the result again.
4. The sink node gets final aggregated result and decrypt it again.

also discuss the various approaches for data aggregation or also discuss the advantage and disadvantages and various performance measures of the data aggregation.

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