

Cluster Based Efficient Location Aware - Source Multicast Routing Approach for Wireless Sensor Networks

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Abstract: A wireless sensor network (WSN) is a network that is made of hundreds or thousands of sensor nodes which are densely deployed in environment with the capabilities of sensing, wireless communications and computations. WSN have constraints on the nodes such as Memory, small-size, low-power consumption, fault-tolerance and scalability which has to be addressed in order to communicate between the nodes network. In source based approaches, as the network size increases the packet size is elongated and causes overhead of processor in the node where as in location based, it requires computation at every forwarding node in a path while looking for the next forwarding node resulting in excessive processing. An Energy Efficient location aware – source multicast cluster based approach for Wireless Sensor Networks is proposed. First, based on the geographic location information clusters are formed. Then, multicast tree is constructed from different sources to the sink to obtain all the possible paths. The proposed approach focuses on lowering the initial network topology, by reducing the number of active nodes and links, thus saving resources and increase the network lifetime.

Keywords: WSN, Routing, Clustering, Multicast.

1. Introduction

Wireless Sensor Networks (WSNs) is a collection of sensor nodes which are densely deployed in an unattended environment and randomly close to or inside of the terrain of interest with the capabilities of sensing, wireless communications and computations in large scale wireless sensor networks. Having a great potential in monitoring systems WSN drawn major attention, recent advances in the technology have made a wireless sensor node cost effective. The sensed data and control messages are exchanged between sensor nodes and the control (sink) nodes via a multihop routing protocol. Therefore, the large scale wireless sensor networks introduces significant scalability concerns and also maintain low energy consumption per node so as to reduce energy consumption and guaranty the network lifetime. One of the main challenges is to set up an architectures and mechanisms that can efficiently scale up with the growing number of nodes that may be required to ensure adequate coverage of large areas of interest and how to avoid significant degradations of the network lifetime [1][2].

The topologies are the major important consideration, In *Flat topologies*, it is difficult to scale up, as the communications between hundreds and thousands of nodes may lead to performance degradation and higher energy consumption in the network. Flooding and Gossiping are example of flat routing protocols [4]. Flooding [5], considered as the simplest means of broadcasting, does not prove to be applicable in the context of sensor networks. This is because flooding leads to collisions and redundant packet receptions

that together deplete sensors of valuable battery power. Gossiping [6] addresses some critical problems of flooding overhead. Gossip protocols consider reduction in the number of retransmissions by making some of the nodes discard the message instead of forwarding it.

In *Hierarchical topologies* [3], involves clustering of nodes in the network, clustering is a technique used to extend the lifetime of a sensor network by reducing energy consumption. A sensor network can be made scalable by forming clusters. Head of the cluster is often referred to as the cluster-head (CH). A CH may be selected pre-assigned by the network designer.

2. Multicast Routing

The routing can be classified as Unicast, multicast and broadcast, Unicast: A node transmits data to a single node in the network. Broadcast: A node transmits data to all other nodes in the network. Multicast: A node transmits data to a selected group of nodes in the network. Broadcast [8] is a natural communication method in a wireless environment. When base stations want to send commands to thousands of sensor nodes, broadcasting is a much more efficient method than unicasting to each node individually. But in broadcast, computation is required at every forwarding node which leads in excess energy consumption. Sending data to a selected number of nodes in the network using Unicast mechanism is a tedious process. Best technique for sending data to selected nodes in the network is multicast. Multicast [7] is the communication paradigm of one-to many or many-to-many, based on defined groups and constituted by

members, whose interest is to receive/share the same information for a specific application. Cluster based, Grid based and Tree based are different approaches that can be considered for multicast routing. Multicast [7] is a technique used to reduce the energy consumption in the network. Multicast routing protocols can be classified in to three categories:

1. The tree-based multicast protocols deliver a multicast packet relying on forwarding states maintained at nodes in a path.
2. The source-based multicast protocols make a path tree at a source, and a multicast packet encoded with the path tree in formation is propagated requiring no states in WSN nodes.
3. In location-based multicast protocols, a multicast packet contains the location information of the destination nodes. It is stateless, like source-based routing, but the packet header size is proportional to the number of destinations and does not increase with the network size.

There are many source based, tree based and location based algorithms for routing with advantages and disadvantages. Reliable location aware routing protocol [17] is one of the locations based routing approach which incorporates fault tolerant clustering protocol for mobile WSN that is energy efficient and also reliable. It also involves a simple range free approach to localise sensor nodes during cluster formation and every time a sensor moves into another cluster. Geographic multicast routing [18] improves the efficiency of forwarding by exploiting the wireless multicast advantage but when dealing with large sensor networks the efficiency of this routing approach might be reduces. . In location based computation is required at every forwarding node which leads to extensive computation

In source based routing technique [19] source-based multicast trees are constructed on demand and the tree exists until the nodes behave as sources. When a node becomes a source node it builds a routing tree from itself (source) to the sink. When the network size is increased, packet size is elongated which results in sharp increase in overhead and energy consumption.

Table 1: Difference between source and location based routing

	Location Based	Source Based
Strengths	No distributed routing control overhead, less path encoding and decoding overhead than source-based	No distributed routing control overhead, relatively smaller forwarding computation than location-based
Weaknesses	Large packet size (location information of destinations), large forwarding computation	Large packet size (path), path encoding and decoding overhead

3. Clustering Approaches

3.1. Hierarchical Schemes

LEACH (Low-Energy Adaptive Clustering Hierarchy) [13]: LEACH provides a balancing of energy usage by random rotation of cluster heads and organized in such a manner that

data-fusion can be used to reduce the amount of data transmission. TL-LEACH [14]: Two-Level Hierarchy LEACH utilizes two levels of cluster heads (primary and secondary). Here, the primary cluster head communicates with the secondary, and the corresponding secondary communicate with the nodes in their sub-cluster. EECS [15]: An Energy Efficient Clustering Scheme in which cluster head candidates compete for the ability becomes cluster head for a given round. In this competition, candidates will broadcast their residual energy to neighbouring candidates. Then a node with higher residual energy is elected as a cluster head. HEED [16]: Hybrid Energy-Efficient Distributed Clustering which uses multi-hop approach, with a focus on efficient clustering by proper selection of cluster heads depending upon the physical distance between nodes.

3.2. Weighted Schemes

Weighted Clustering Algorithm (WCA) [12]: This approach is a non-periodic procedure in the election of a cluster head, invoked on demand every time a network topology is reconfigured. When a sensor loses the connection in the cluster, the election procedure is invoked to find a new clustering topology. Cluster head election procedure: The election procedure is based on the combined weight. The combined weight is calculated by each node and broadcasted over the network. The node with smallest W_v is chosen as the cluster head.

3.3. Heuristic Algorithms

Linked Cluster Algorithm (LCA) [9]: Here each node is assigned a unique ID number and has two ways of becoming a cluster head. The first way is the node should have a highest ID number. The second way, if none of its neighbors are clusterheads, then that node can become a cluster head. Linked Cluster Algorithm 2 (LCA2): eliminates the election of an unnecessary number of cluster heads by introducing the concept of a node being covered and non-covered. A node is said to be covered if one of its neighbors is a cluster head. Cluster heads are elected starting with the lowest ID node among non-covered neighbors. Connectivity Cluster Algorithm [10]: Here the number of node neighbors is broadcasted to the surrounding nodes. Instead of looking at the ID number, the connectivity of a node is considered. The node with the highest connectivity is elected cluster head. Max-Min D-Cluster Algorithm [11]: Distributed cluster head election procedure, where no node is more than d (d is a value selected for the heuristic) hops away from the cluster head. It provides load balancing among clusterheads.

4. Proposed System

Wireless sensors can be deployed in an unattended environment with the capabilities of sensing, wireless communications and computations. But the limitations of the sensor nodes such as battery, low memory and processing speed play a major role in routing with respect to large scale wireless sensor networks. Traffic congestion which requires extensive computation decreases the life time of the nodes and in turn the network. The different authors have discussed various routing techniques in both source and location based routing approaches, from the study it is found that a routing

approach with minimum computation, effective utilization of resources and congestion control mechanism is essential to increase the network lifetime. A new approach can be designed by incorporating some features from location based and source based approach to improve efficiency of routing. The proposed work aims at finding a new approach by considering the location based and source based approaches.

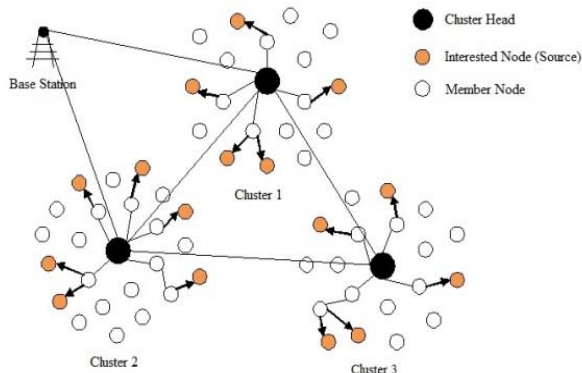


Figure 1: System Architecture

The figure 1 shows the architecture of the proposed approach. The proposed approach works in two stages: stage 1 – cluster formation and stage – 2 multicast tree constructions.

Assumptions

1. There is only one base station.
2. At least one node in a cluster must have GPS equipped in it.
3. No direct communication between member node and base station.

Stage 1: Cluster Formation

Here clusters are formed based on location information by electing GPS equipped node as a cluster head. The nodes which are within the sensing range of the cluster head are assigned to that particular cluster. The cluster head will have Ids of all its member nodes.

Algorithm - 1

Deterministic cluster head placement with GPS equipped in it.

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For i = 1 to NumberofNodes do
  If position (Node [i]) ∈ CH range [j]
    CH [j] ← Node [i]
  // Node i is assigned to Cluster j
End if
End for

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Stage 2: Multicast tree construction

After the cluster formation, base station will have the Ids of all the cluster heads in the network. Base station will broadcast the data to all the cluster heads in the network. After receiving the data, cluster head will broadcast hello packet to its member nodes about the data. On receiving the hello packet, interested nodes will acknowledge the cluster head for the data. A source based multicast tree is constructed from cluster head to all the interested nodes (source) in the cluster. Finally cluster head will send the data to all the sources in the cluster and acknowledge the base station with its Id about the data usage in that particular cluster.

Algorithm – 2

Base station broadcasts data to all the CH in the network

For each node i of cluster j

CH[j] sends hello packets

If Node[i] needs data

Node[i] sends ACK to CH[j]

// Source based multicast tree construction

CH[j] sends data to Node[i]

End if

End for

CH sends ACK to BS about the data usage in the cluster with its ID

5. Analysis

Proposed approach optimizes the source and location based routing techniques to reduce the energy consumption in the network. Location information is obtained using GPS equipped cluster head and the nodes within the range of that cluster head are grouped into one cluster. As the nodes are placed deterministically, care is taken to cover the entire large area network. Using GPS is little expensive but better approach to minimize energy consumption rather than using flooding or broadcasting techniques. All the nodes information is stored in cluster head and cluster heads information in the base station. Base station will forward data only to cluster heads rather than all the nodes in the network. Hence reduces the energy consumption. By creating the source based multicast tree for interested nodes, hence unnecessary transmission of data to non interested nodes is avoided which can lead to minimum energy consumption. The analysis of the proposed approach will be carried out by varying the number of clusters in the network and source nodes in each cluster.

6. Conclusion

As wireless sensor networks are resource constrained network. The proposed approach optimizes the source and location based routing techniques in order to reduce the energy consumption of the network. Clustering is considered to reduce the energy computation at every node and multicast is used to reduce the unnecessary transmission of data to all the nodes as a result energy consumption of the network is considerably reduced.

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