Reliable Energy Conservation in Wireless Sensor Networks using Flooding Techniques

L. Nalini Joseph[1], Dr.S.Shanmugavel[2]

[1]Research Scholar, [2]Professor
Department of Electronics &Communication Engineering,
College of Engineering, Anna University,
Chennai, India.

Abstract: A Comparison of Performance in terms of Energy conservation in Wireless Sensor Networks using different Flooding mechanism **has** been analyzed. The following flooding mechanisms analyzed are Classical Flooding, Location Aided Flooding, Adaptive Location Aided Flooding; Diagonal arc based Location Aided Flooding, Diagonal arc based Location Aided Flooding with reliability is considered for the study. The various mechanisms save energy when compared to conventional flooding schemes.

Keywords: *Sensor Networks, Flooding, Virtual Grids, ALAF, DALAF.*

1. Introduction:

Sensor networks are composed of a large number of sensor nodes that are densely deployed either inside the phenomenon or very close to it [1]. The position of sensor nodes need not be engineered or predetermined. This allows random deployment in inaccessible terrains or disaster relief operations. On the other hand, this also means that sensor network protocols and algorithms must possess self-organizing capabilities [2]. Another unique feature of sensor networks is the cooperative effort of sensor nodes [1]. Sensor nodes are fitted with an onboard processor. Instead of sending the raw data to the nodes responsible for the fusion, they use their processing abilities to locally carry out simple computations and transmit only the required and partially processed data.

Conventional protocols use classical flooding [] for disseminating data in a sensor network. Flooding [11] is also used as a preprocessing step in many routing protocols in networks for disseminating route discovery requests. Information dissemination protocols are used in networks for distributing the link state information. Routers in the Internet periodically use flooding to update link state information at other nodes.

Despite many of its uses, flooding suffers from disadvantages such as the broadcast storm problem [12]. There are situations when duplicated messages are sent to the same node and also if two nodes share the same observing region, neighbor nodes receive duplicated messages. The flooding protocol does not take into account of the available energy resources.

Sensor nodes are typically characterized by small form-factor, limited battery power, and a small amount of memory. So there is a need for an energy-efficient flooding mechanism for information dissemination in distributed sensor networks.

2. Adaptive location aided flooding (ALAF)

To overcome the above issues, the concept of integrating non-uniform virtual grids into location aided flooding to form Adaptive Location Aided Flooding (ALAF) is proposed. In ALAF [3], the grids with dense deployment are further sub-divided into smaller grids thereby non-uniform grids of dissimilar grid sizes are present in the sensor network. The node list is frequently stripped off avoiding excessive increase in its size, which in turn conserves appreciable amount of energy on location aided flooding for information transfer to neighbor nodes or to the sink. The description of ALAF structural formation, functional design, its operation and energy conservation principals are presented in this chapter.

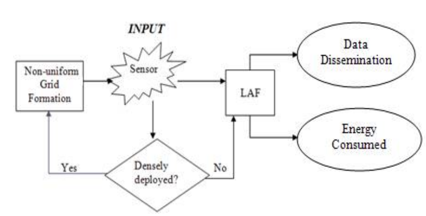

Fig. 1 Block Diagram of ALAF

In ALAF, the LAF[2] mode with densely populated sensor nodes are converted into non-uniform virtual grids for location aided flooding as shown in Fig 1. The virtual grid formation varies as and when the node density increases in the specific location. If the number of nodes in a grid exceeds a certain threshold, then the grid is further split into grids of smaller dimensions. Each node associates itself with a virtual grid and is classified as either gateway node or internal node.

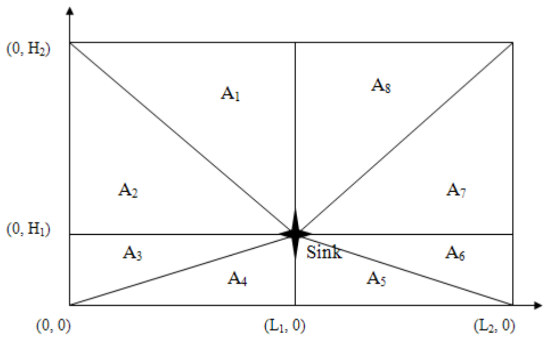

Fig. 2 Non Uniform Grid Formation in ALAF

A source node starting the ALAF broadcasts the packet to all its neighbors. The receiving node does further broadcasts. When a gateway node receives a packet from within its virtual grid, it checks to see if any of its neighbors within the same virtual grid have not yet received the packet. This is done by comparing the node list of the packet with the neighbor list of the node. If such nodes exist, then the gateway node appends the ids of those nodes to the node list of the packet and forwards it to the neighbor nodes that still have not received the message. When a gateway node receives a packet from another gateway node, it strips the packet of its node list and adds its own id and all its neighbors' ids and forwards the packet to all its neighbors. Thus, the packet becomes shorter as it moves across the virtual grids and increases in size as it moves within a virtual grid. When an internal node receives a packet, it modifies the node list of the packet. It includes the ids of all its neighbors in the node list and forwards it to its neighbors if they have not already received a message.

The algorithm for grid formation and node classification is given below:

1. Divide the sensor field into grids based on topography and grid size.
2. For each node,

- Based on its location in one of the grids formed, set the grid id and maintain the node count in each grid.
- If the node count of the grid exceeds threshold value,
- Get the dimensions of the grid and the new grid size.
- Split the grid based on the input parameters.
- Maintain the count of number of grids formed.
- Set new grid id for the node based on its location in one of the new grids formed.
- Identify the neighbors and store in the neighbor list.
- Classify the node
- If all of its neighbors belong to the same grid as that of the node, then set its node type as internal.
- If any of its neighbors belong to a different grid than that of the node, then set its node type as gateway.

3.1. DATA DISSEMINATION:

A source node start broadcasts the packet to all its neighbors. The receiving node does further broadcasts in one of the following ways:

When a gateway node receives a packet from within its virtual grid, it checks to see if any of its neighbors within the same virtual grid have not yet received the packet. This is done by comparing the node list of the packet with the neighbor list of the node. If such nodes exist, then the gateway node appends the ids of those nodes to the node list of the packet and forwards it to the neighbor nodes that still have not received the message.

When a gateway node receives a packet from another gateway node, it strips the packet of its node list and adds its own id and all its neighbors' ids and forwards the packet to all its neighbors. Thus, the packet becomes shorter as it moves across the virtual grids and increases in size as it moves within a virtual grid.

When an internal node receives a packet, it modifies the node list of the packet. It includes the ids of all its neighbors in the node list and forwards it to its neighbors.

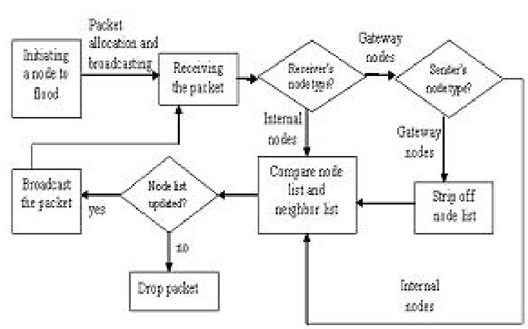

Fig 3. Data Dissemination in ALAF

The proposed algorithm for data dissemination is given below:

1. The source node creates a packet with its id, sequence number, node list, grid id, node type, node list length. The node list contains its id and the ids of all its neighbors.
2. The source node broadcasts the packet to its neighbors.
3. The receiving node checks to see whether the packet's sequence number is already in its received list of sequence numbers.
    a. If so, it drops the packet.
    b. Else, it stores the sequence number of the packet it receives and sets its id, grid id, node type in the packet.
        i. If it is an internal node, it compares its neighbor list with the node list in the packet.
            1. If there are nodes in the neighbor list not present in the node list, it adds those nodes to the node list and broadcasts the packet to its neighbors.
            2. Else, it drops the packet.
        ii. If it is a gateway node, it checks the node type in the received packet.
            1. If it has received from an internal node, it compares its neighbor list with the node list in the packet.
                a. If there are nodes in the neighbor list not present in the node list, it adds those nodes to the node list and broadcasts the packet to its neighbors.
                b. Else, it drops the packet.
            2. If it has received from a gateway node, it checks the grid id in the received packet.
                a. If it has received from a node in the same grid, it compares its neighbor list with the node list in the packet.
                    i. If there are nodes in the neighbor list not present in the node list, it adds those nodes to the node list and broadcasts the packet to its neighbors.
                    ii. Else, it drops the packet.
                b. If it has received from a node in a different grid, it strips off the node list, adds all its neighbors to the node list and broadcasts the packet.

This method uses the concept of non-uniform virtual grids to partition the sensor nodes into groups of gateway nodes and internal nodes. It exploits the location information available to sensor nodes to prolong the lifetime of sensor network by reducing the redundant transmissions that are inherent in flooding.

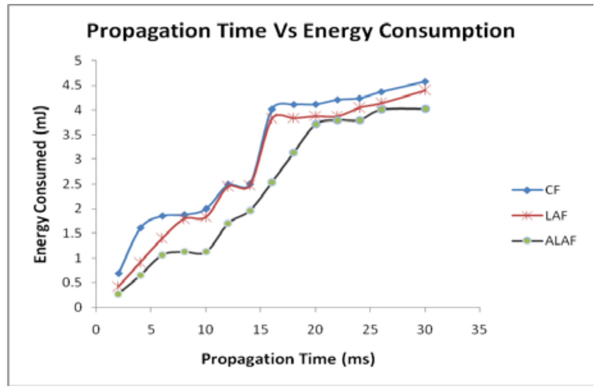

Fig 4. Propagation Time vs energy consumption in ALAF with other flooding techniques

A Graph was plotted for the propagation time versus energy consumed . the above results states the energy consumed by ALAF was minimum than the other flooding schemes. However the non uniform grids some time causes non association of sensor nodes to any of the virtual grids, which in turn cause the lack of information transfer of those sensor nodes. The non uniform grids formed in the network created more virtual sub spaces, whose area cannot be monitored. The unmonitored subspace causes loss in share of information and increased energy consumption of the overall sensor network. These problems are addressed in the work Diagonal-arc based ALAF (DALAF) model, which takes into account of available energy resources. The need for an energy-efficient flooding mechanism for information dissemination in distributed sensor networks is realized with DALAF.

ALAF[] must make very conservative connectivity assumptions because it guesses at connectivity[] (based on a radio model) instead of directly measuring it. Being conservative requires more nodes to stay active than necessary, leading to less energy conservation. Therefore, a need of Flooding mechanism for energy conservation without relying on location information arises This motivates Diagonal based Energy Conservation (DALAF), which, unlike ALAF, does not rely on location information. Further, DALAF itself directly and adaptively measures network connectivity and thus can find network redundancy more accurately so that more energy can be conserved by nullifying subspace and initiate switch off the redundant node radio signal to reduce redundant transmissions, thereby saving energy.

4. Diagonal Arc based Adaptive Location Aided Flooding

This paper has been motivated to develop a Diagonal based Energy Conservation flooding (DALAF) mechanism for energy conservation. DALAF identifies network redundancy and measures network mobility more accurately so that more energy can be conserved by nullifying subspace and initiate switch off the redundant node radio signal. The steps involved in DALAF algorithm is as discussed below.

4.1 Determining Network Redundancy

DALAF organizes nodes into overlapping clusters that are interconnected to each other as shown in Figure 2. A cluster is defined as a subset of nodes that are mutually "reachable" in at most 2 hops. A cluster can be viewed as a circle around the cluster-head with the radius equal to the radio transmission range of the cluster-head. Each cluster is identified by one cluster-head, a node that can reach all nodes in the cluster in 1 hop. A gateway is a node that is a member of more than one cluster. The gateway nodes connect all clusters together to ensure overall network connectivity. A node is ordinary if it is neither a cluster head nor a gateway node and is thus redundant.

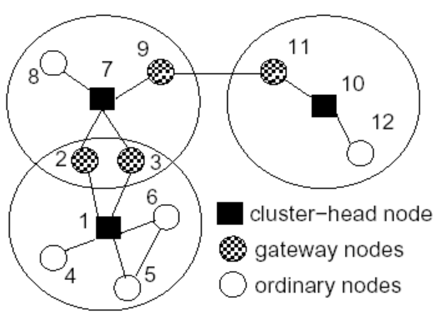

Figure 5: Example of DALAF cluster formation.

4.2 Distributed Cluster Formation

In order to elect cluster-heads and gateway nodes, each node periodically broadcasts a discovery message that contains its node ID, its cluster ID, and its estimated lifetime. The circle around the cluster-head indicates the radio transmission range. A node's estimated lifetime can be conservatively set by assuming the node will constantly consume energy at a maximum rate until it runs out of energy. While forming clusters, DALAF first elects cluster heads, then elects gateways to connect clusters

4.3 Cluster -head Selection

A node selects itself as a cluster-head if it has the longest lifetime of all its neighbor nodes, breaking ties by node ID. Each node can independently make this decision based on exchanged discovery messages. Each node sets its cluster ID to be the node ID of its cluster-head.

4.4 Gateway Node Selection

Among the gateway nodes, those nodes that can hear multiple cluster-heads are primary gateway nodes and those that can hear a combination of cluster heads and primary gateway nodes are secondary gateway nodes. When multiple gateway nodes exist between two adjacent clusters, DALAF suppresses some of them in order to conserve energy since these gateway nodes are redundant. Gateway selection is determined by several rules. First, primary gateway nodes have higher priority than secondary gateway nodes since at least two secondary gateway nodes, instead of just one primary gateway node, are needed to connect adjacent clusters. Second, gateway nodes with more cluster-head neighbors have higher priority, since this will require fewer nodes to be kept awake. Third, gateway nodes with longer lifetimes have higher priority in order to balance node energy. Note that the gateway selection algorithm does not guarantee that only one or one pair of gateway nodes exists between adjacent clusters. In order to support gateway selection, DALAF extends the basic discovery message to include the IDs of the clusters that a gateway node can connect.

Figure 5 shows an example of DALAF cluster formation in which all nodes have the same estimated network operational lifetime. Nodes 1 and 10 can directly decide they are the cluster-heads because they have the lowest ID of all of their neighbors. Node 7 becomes a cluster-head after nodes 2 and 3 choose node 1 as their cluster-head. Nodes 2 and 3 are primary gateway nodes because they are neighbors of two cluster-heads: nodes 1 and 7. Note that one of nodes 2 and 3 is redundant. Nodes 9 and 11 are secondary gateway nodes between clusters 7 and 10.

4.5 Adapting to Network Mobility

With only a subset of the nodes active, it is possible that network mobility could cause a loss of connectivity. If a cluster-head moves then it might no longer be able to serve as a cluster-head. DALAF uses mobility prediction in order to maintain network connectivity.

By estimating how soon a cluster-head will leave its current cluster and inform all nodes in the cluster of that time, the clustered nodes can power themselves on before the cluster-head leaves its cluster. This time is estimated as R/s where s is the cluster-head's current speed and R is its radio transmission range.

Suppose if the R/s estimate is too large, the connectivity between the moving cluster-head and some nodes might be lost before this time. However, if this estimate is too small, DALAF will not be able to conserve any energy. In our DALAF implementation, we set the estimate as R/4s to balance energy conservation and connectivity. We extend the basic discovery message to include the predicted cluster-leaving time. All nodes in a cluster should wake up to reconfigure clusters before the shorter of Ts and the cluster-leaving time of its current cluster-head. The cluster-leaving time estimate is used analogously in the gateway node selection process.

ALAF uses a similar method for dealing with mobility but it anticipates hand-offs by using location information, whereas DALAF uses only local measurements. With such global information, ALAF may have more accurate mobility predications, but DALAF is more practical and localized in nature. DALAF algorithm used to achieve energy conservation has been summarized as follows:

DALAF: ALGORITHM

Step 1: Divide the sensor field into cone shaped grids based on topography and
grid size.
Step 2: For each node,
a. Based on its location in one of the grids formed, set the grid id and maintain the node count in each grid.
b. If the node count of the grid exceeds threshold value,
i. Get the dimensions of the grid and the new grid size.
ii. Split the grid based on the input parameters.
iii. Maintain the count of number of grids formed.
c. Set new grid id for the node based on its location in one of the new grids formed.
d. Identify the neighbors and store in the neighbor list.
e. Classify the node
i. If all of its neighbors belong to the same grid as that of the node, then set its node type as internal.
ii. If any of its neighbors belong to a different grid than that of the node, then set its node type as gateway.

Step 3: The source node creates a packet with its id, sequence number, node list, grid id, node type, node list length. The node list contains its id and the ids of all its neighbors.
Step 4: The source node broadcasts the packet to its neighbors.

Step 5: The receiving node checks to see whether the packet's sequence number is already in its received list of sequence numbers.
c. If so, it drops the packet.
d. Else, it stores the sequence number of the packet it receives and sets its id, grid id, node type in the packet

	CF in (mj)	LAF in (mj)	ALAF in(mj)	DALAF in(mj)	DALAF Single Path	DALAF Multi Path
2	0.068	0.423	0.282	0.221	0.221	0.156
4	1.608	0.915	0.66	0.486	0.486	0.296
6	1.849	1.402	1.07	0.822	0.822	0.524
8	1.874	1.795	1.129	1.093	1.093	0.636
10	1.996	1.834	1.131	1.146	1.146	0.951
12	2.486	2.455	1.706	1.626	1.626	1.263
14	2.498	2.475	1.971	1.79	1.79	1.334
16	4.013	3.826	2.542	2.034	2.034	1.517
18	4.106	3.836	3.144	2.765	2.765	1.639
20	4.11	3.876	3.714	3.602	3.602	1.944
22	4.204	3.878	3.801	3.771	3.771	2.249
24	4.235	4.05	3.802	3.792	3.792	2.553
26	4.241	4.05	4.01	3.986	3.989	2.98
28	4.365	4.14	4.012	4.007	4.007	3.468
30	4.572	4.404	4.028	4.015	4.015	3.773

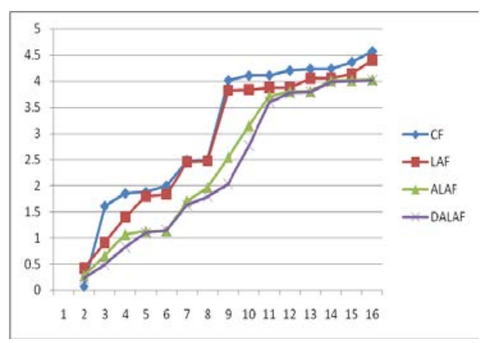

Figure 6. Propogation Time Vs. Energy Consumption

DALAF algorithm which has been reported above has been tested and the evaluation of its performance has been reported in the subsequent section.

5. Results and Findings

We have developed a simulation environment in NS2 to evaluate the performance of DALAF and compared it with ALAF algorithm for energy conservation. It was found that DALAF protocol achieves higher with reliable energy savings when compared with classical flooding, LAF and ALAF. We also found that the nodes with a higher degree (i.e., nodes with more one-hop neighbors) disseminate more data per unit energy in both LAF and modified flooding compared to classical flooding. Thus, dense sensor networks are likely to benefit more from using the DALAF protocol for data dissemination in terms of energy savings.

6. Conclusion and Future Directions

Performance analysis in terms of energy consumption is taken and compared for the Classical flooding (CF), Location aided flooding(LAF),Adaptive location aided flooding(ALAF) and Diagonal Arc based Adaptive Location Aided Flooding with reliability,(DALAF) is presented . This mechanism DALAF is capable of measuring reliable network mobility and network redundancy more accurately so that more energy can be conserved by nullifying subspace and initiate switch off the redundant node radio signal.

References:

[1] I.Akyildiz, W.Su, Y.Sankarasubramaniam, and E.Cayirci, "A survey on Sensor Networks," *IEEE Communications Magazine*, vol. 40, Issue:8, pp.102-114, August 2002.

[2] Harshavardhan Sabbineni and Krishnendu Chakrabarty, "Location-Aided Flooding: An Energy-Efficient Data Dissemination Protocol for Wireless Sensor Networks," *IEEE transactions on computers*, vol. 54, no. 1, Jan 2005, pp.36-46.

[3] Nalini.L. and Uma.G.V., "An Energy Efficient Adaptive Location Aided Flooding Protocol for Wireless Sensor Networks" Asian Journal of Information Technology 5(12):1485-1491,2006,Medwell Online ,2006

[4] Nalini.L.,Shanmugavel.S " Conservation of energy in Wireless Sensor Networks using Diagonal arc based Adaptive Location Aided Flooding Mechanism"- European Journal of Scientific Research ISSN 1450-216X vol.51.No.1(2011)PP 44-52

[5] Z. Haas, J. Halpern, and L. Li, "Gossip Based Ad Hoc Routing," IEEE Infocom Conf., pp. 1702-1706, 2002.

[6] J. Jetcheva, Y. Hu, D. Maltz, and D. Johnson, "A Simple Protocol for Multicast and Broadcast in Wireless Ad Hoc Networks," Internet Draft: draft-ietf-manet-simple-mbcast-01.txt, July 2001

[7] J. Kulik, W.R. Heinzelman, and H.Balakrishnan, "Negotiation- Based Protocols for Disseminating Information in Wireless Sensor Networks," Wireless Networks, vol. 8, pp. 169-185, 2002.

[8] K. Whitehouse and D. Culler, "Calibration as Parameter Estimation in Sensor Networks," ACM Int'l Workshop Sensor Networks and Applications, pp. 59-67, 2002

[9] R. Williams, The Geometrical Foundation of Natural Structure: A Source Book of Design. New York**:** Dove Publications, 1979.

[10] J. Wu and F. Dai, "Broadcasting in Ad Hoc Networks Based on Self-Pruning," Proc. Infocom, pp. 2240-2250,2003

[11] Jie Lian, Kshirasagar Naik and Gordon B. Agnew(2006), Modelling and Enhancing the Data Capacity of Wireless Sensor Networks

[12] K.P. Birman, M. Hayden, O. Ozkasap, Z. Xiao, S. Ni, Y. Tseng, Y.Chen, and J. Sheu, "The Broadcast Storm Problem in a Mobile AdHoc Network," Proc. ACM/IEEE Int'l Conf. Mobile Computing andNetworking, pp. 151-162, Aug. 1999.