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Improved GAF in Wireless Sensor Network

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Abstract-Now a day in our daily life a wireless technology has been commonly used. There are various advantages of using wireless network but also there are lots of challenges to make a wireless network useful. Its energy consumption is a crucial challenge which affects the wireless network performance. Many routing protocols in WSN are used for the same purpose. In WSN, Geographic Adaptive Fidelity (GAF) is a location based routing protocol which transmits data on the basis of location information of destination node. It works in three phases i.e. discovery phase, sleeping phase and active phase. Optimized GAF is improved version of Basic GAF in which the discovery phase is improved to reduce the energy used by nodes in discovery phase and increases the lifetime of network. Optimized GAF is used for the static nodes. The proposed protocol, Improved GAF, is used for dynamic nodes. In this, at every simulation run the number of nodes deployed in the network will change. This gives different results in each simulation run. Implementation of proposed Improved GAF protocol is done using MATLAB.

Index Terms- Energy Efficiency, GAF, Improved GAF, WSN.

1. INTRODUCTION

Wireless Sensor Network (WSN) has gained world-wide attention in recent years due to the advances made in wireless communication. Efficient design and implementation of wireless sensor networks has become a hot area of research. A wireless sensor network consists of spatially distributed sensors without using wires to sense the different conditions such as temperature, sound, humidity, pressure, motion or pollutants, and to transmit their data through the network to a base station. Because of no fixed infrastructure WSN are more flexible for obtaining data from the environment. The basic task of sensor nodes is sensing, gathering and processing the data while communicating with other connected nodes in the network.

WSN is having a characteristic of sending data from one sensor node via another by coordinating with each other to a base station or sinks, these sinks may be stationary or moving while receiving data or waiting for a query response. While moving, a sink should continuously update its topological position information in the sensor nodes to maintain paths. This may require large signalling overhead, resulting in excessive energy consumption.

WSNs nodes are battery powered which are deployed to perform a specific task for a long period of time, even years. Because of the advantages of wireless sensor network they have been employed in a wide range of applications [1].

Routing protocols in WSNs are responsible for discovering and maintaining the routes in the network. In WSNs routing protocols might be different depending on the application and network architecture. In WSN, routing protocols are divided into three main categories such as data centric, hierarchical and location based routing protocols [2] [4].

Data Centric Routing Protocols

Data centric routing is a query based. All nodes participating in routing play the same role of collecting data and communicating with the sink. The sink sends queries to certain regions and waits for data from the sensors located in the selected regions. Since data is being requested through queries, attribute based naming is necessary to specify the properties of data. SPIN is the first data-centric protocol, which considers data negotiation between nodes in order to eliminate redundant data and save energy.

Hierarchical Routing Protocols

Hierarchical routing is a cluster based routing. The goal of the protocol is to perform energy-efficient routing in WSNs by avoiding an overload of sink nodes by too many received messages, as well as reducing the amount of overall message transmissions. To achieve this, nodes are grouped into clusters, where each cluster has cluster head and cluster nodes. The higher energy nodes are used to process and send the information while low energy nodes are used to perform the sensing in the proximity of the target.

Location Based Routing Protocols

Sensor nodes are addressed by means of their locations. In most cases location information is needed in order to calculate the distance between two particular nodes so that energy consumption can be estimated. Each node calculates the distance to his neighbor node from the incoming signal strength. In some location-based schemes in order to save energy, the nodes must change their state from active to sleep if there is no activity. [3] It saves the energy of nodes by reducing the number of transmissions. The query is send only to the particular region using the location of the sensor nodes.

2. RELATED WORK

Wireless sensor network is a network consisting of sensor nodes. To transmit information from one node to another routing protocols are used. Routing protocols select the best route in the network for transmitting data. The designing of routing protocol depends upon the application where it has to be used. There are various challenges in the wireless sensor networks and limited energy is one of the basic constraints in WSN. Energy of the network depends upon the battery power. It directly affects the performance of the whole network. Different authors propose different schemes for reducing energy consumption. Some of the schemes are:

To save the nodes energy Hierarchical Geographic Adaptive Fidelity (HGAF) is proposed [5]. This will also increase the network lifetime. It saves power by increasing the size of GAF cell, using a layered structure in order to select an active node in each cell. Result shows that HGAF performs better than GAF in case of energy efficiency and packet delivery ratio. Also when there is high node density and a cell is further divided into four sub cells then the lifetime of network is increased 200% in HGAF comparison to GAF.

The extended version of HGAF i.e. eHGAF (extended HGAF) is further improved to save the energy consumption by dividing the sensor field in an efficient way and increase the lifetime of network [6].

In [7], a topology management protocol known as GAF with COnnectivity-awareness (GAF&Co) is proposed. This protocol is derived from GAF protocol. The network is divided into hexagonal cells in place of virtual grids. The main objective of this is to maintain the connectivity of a network and to avoid routing holes. This also helps in energy consumption by activating an energy-saving mode for the redundant nodes.

Authors in [8] [9], studies the advances made in Geographic Adaptive Fidelity (GAF) protocol. To reduce energy consumption CODE (COordination-based data Dissemination) protocol is proposed using GAF protocol and is deployed above GAF. In GAF, unnecessary nodes are turned off while keeping a constant level of routing fidelity whereas For the purpose of energy cost reduction CODE is based on the grid structure to transfer data along a shortest path as well as GAF to reduce consumption of energy and data collision. Phases in CODE protocol are: Data announcement, Query transfer and Data dissemination.

GAF reduces the energy consumption of network by turning off unnecessary nodes. To make it more energy efficient a new backbone algorithm for GAF is proposed in [10] known as GAFBone. In this the network is divided into grids in such a way that the number of rows and columns are multiples of three. GAFBone works in three phases and improve the performance of the network. The number of active nodes has decreased without affecting the routing process. In this paper, GAFBone is simulated using MATLAB.

In [11], authors designed and evaluated a protocol named as Geographic and Energy Aware Routing (GEAR). This is an energy efficient routing algorithm. It eliminates the concept of flooding and transmits a query to the target region by using energy aware neighbor selection. Recursive Geographic Forwarding is used to disseminate the packet inside the target region. In this paper, author evaluated this protocol using simulation. Results showed that for non-uniform traffic distribution, it exhibits noticeably longer network lifetime than non-energy aware geographic routing algorithms. GEAR uses energy aware and geographically informed neighbor selection to route a packet towards the target region. This strategy attempts to balance energy consumption and thereby increase network lifetime. Within a region, it uses a recursive geographic forwarding technique to disseminate the packet.

In [12], authors proposed an improvement over the GAF protocol in wireless sensor networks. The division of network and selecting a proper cluster head also affects the overall performance of the network. The division of network is based on the calculation that according to the position information node belongs to which grid.

3. GAF (GEOGRAPHIC ADAPTIVE FIDELITY)

GAF is a location based routing protocol which uses the location information for sending the data to the sink node. GAF is an energy-aware routing protocol primarily proposed for MANETs, but can also be used for WSNs because it favors energy conservation. GAF is based on mechanism of turning off unnecessary sensors while keeping a constant level of routing fidelity (or uninterrupted connectivity between communicating sensors). In GAF, sensor field is divided into grid squares. It works in three states:

- Discovery Phase
- Active Phase
- Sleep Phase

Transition states of GAF are shown in Figure 1. At the time of discovery all the nodes are awake and transmit discovery messages to select the higher energy node to become active. [13] This process takes Td time. Ta time is predefined time for the node to be in the active state and Ts time is a predefined time for sleep state.

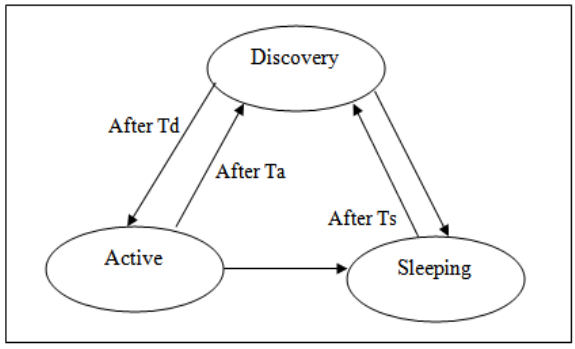

Figure 1: Transition states of GAF

4. IMPROVED GAF (PROPOSED WORK)

In Basic GAF protocol, an active node is selected by calculating the highest remaining energy of a node. Every time node enters into a discovery phase to select next active node. To reduce the energy consumption of nodes and increase the lifetime of network, the discovery phase of GAF protocol is improved [14]. The working of the proposed protocol is based on Optimized GAF. Change in transition states in the intervals of discovery phase in an Improved GAF, is shown in Figure 2.

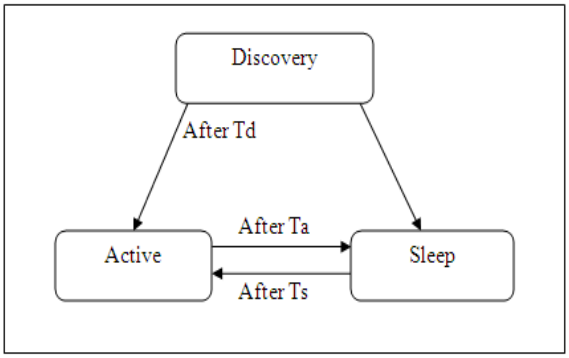

Figure 2: Transition States of Improved GAF

Optimized GAF works on a static number of nodes Improved GAF works on the dynamic number of nodes. This implies that the number of nodes in the network is not fixed. It keeps on changing with every new deployment.

In the discovery phase, a sequence of nodes to become active will be assigned to the nodes having maximum remaining energy. From this sequence some of the nodes will be selected to become active before the next discovery phase. The discovery phase won't be repeated for the selection of each active node but only for finding the sequence of active nodes. After predefined Active Time (Ta), next sequenced node will become active directly without entering into the discovery phase. In this way the energy consumed by the nodes in discovery process will be saved. The next sleeping node after Sleeping Time (Ts) in the sequence will awake before the expiry of active node's Leaving Time.

5. RESULTS AND DISCUSSIONS

The performance of GAF and Improved GAF has been analyzed using MATLAB. Table 1 shown below summarized the simulation parameters. The performance metrics comprises of Percentage of Dead Nodes, Average Balance Energy are discussed in next section.

TABLE I: Simulation Parameters

Parameters	**Values**
Number of Nodes	Not Fixed (Ranging from 80-200)
Environment Size	100 x100
Number of Grids	9
Sink Position	(100,100)
Initial Energy of Each Node	0.5 Unit
Simulator	Matlab 2009
Operating System	Windows 7

A. Simulation Results

The schemes, Basic GAF and Improved GAF scheme have been implemented using MATLAB software. The goal of the implementation is to demonstrate the advantages of Proposed Scheme over Basic GAF Schemes. The simulation results are evaluated by comparing both schemes on the basis of different parameters such as percentage of dead nodes and balance energy in ten different simulation runs.

Energy Efficiency

In proposed protocol, the improvement of discovery phase directly affects the energy consumption of the whole network. Simulation results are concluded by observing 10 different simulation runs after the random deployment of sensor nodes of different range. The number of sensor nodes deployed in the network is not fixed. They keep on changing in every simulation run. The network is divided into 9 equal size grids. Numbers of Dead Nodes in both simulated schemes Basic GAF and Improved GAF Scheme are shown below. Figure 3 shows the dead nodes in Basic GAF scheme corresponding to the number of nodes deployed in a network. Figure 4 shows the dead nodes in Improved GAF scheme corresponding to the number of nodes deployed in a network.

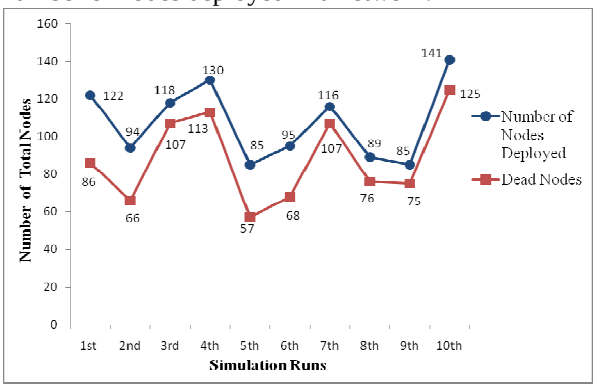

Figure 3: Total number of nodes deployed and its corresponding dead nodes in Basic GAF Scheme.

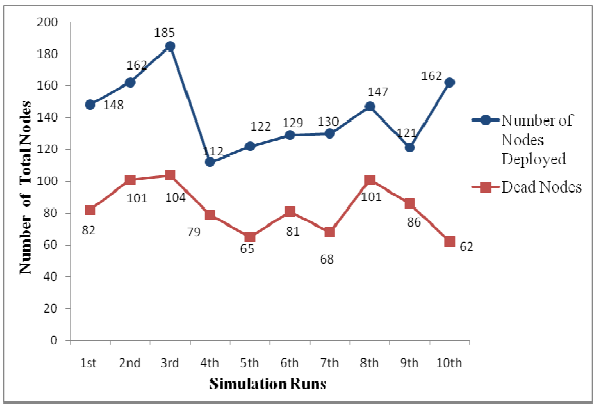

Figure 4: Total number of nodes deployed and its corresponding dead nodes in Improved GAF Scheme

The number of total nodes deployed in a network and its corresponding dead nodes in network are used to find the percentage of the dead nodes in a network. Figure 5 shows the percentage of dead nodes in network. This shows that the percentage of dead nodes in a Basic GAF is more as compared to Improved GAF. Improved GAF consumes less energy of the network nodes.

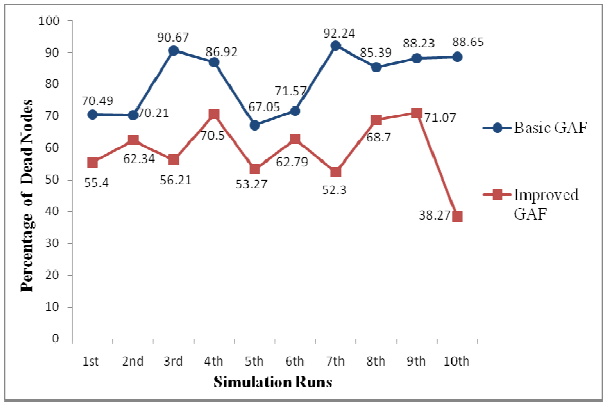

Figure 5: Comparison of Percentage of Dead Nodes

The comparison graph between Basic GAF and Improved GAF on the basis of Average Balance Energy of Nodes is shown in Figure 6. This result analysis is similar to the comparison on the basis of dead nodes. A result shows that in Improved GAF Average Balance Energy of the Nodes is more as compared to the Average Balance Energy of Nodes in Basic GAF.

Figure 5 and Figure 6 clearly shows that the Network survivability is increased in Improved GAF scheme and it is performing better than Basic GAF scheme.

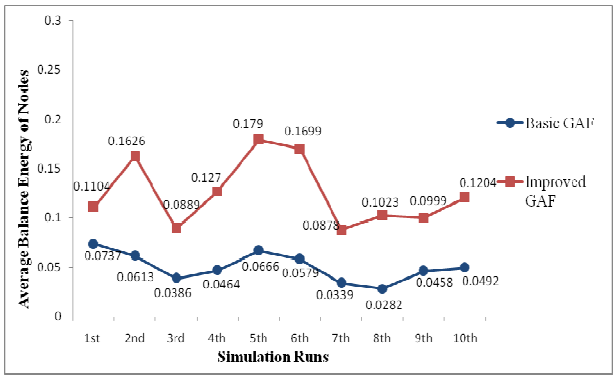

Figure 6: Comparison of Average Balance Energy of Nodes

6. CONCLUSION

Tables Wireless sensor network is the most popular technology used in various different applications. The

most significant benefits of wireless sensor network are the small size nodes which can fit into any type of environment, which may be accompanied with a drawback, i.e., resource constraints. The limited energy is the main challenge to overcome. In order to reduce the energy consumption, Optimized GAF is proposed which is an improvement over Basic GAF scheme. But the Optimized GAF uses the static nodes at the time of deployment which sometimes is not realistic. Therefore, this thesis proposed an Improved GAF which is an improvement over Optimized GAF. Improved GAF uses the dynamic nodes for the deployment. The proposed protocol is implemented using MATLAB. One major advantage of this work is its simplicity. The whole network is divided into square shape grids of equal size. Active node is selected on the basis of highest remaining energy of the nodes in the grid. In this research work, energy consumption is minimized by improving the Discovery Phase of Basic GAF. The Discovery Phase won't be repeated for the selection of each active node but only for finding the sequence of active nodes after Discovery Time (Td). By the implementation result of Basic GAF and Improved GAF, it can be concluded that Improved GAF becomes more energy efficient in comparison to existing Basic GAF Scheme. In Improved GAF Scheme, dead nodes are lesser than the Basic GAF. Proposed scheme needs less energy of nodes hence, increases the balance energy of the nodes and network will survive more with Improved GAF

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