A NEW MAC WITH TRAFFIC AWARE RELAY NODE DEPLOYMENT FOR CLUSTER COMMUNICATION IN WIRELESS SENSOR NETWORKS

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Abstract: Energy conservation is one of the primary goals for majority of Medium Access control (MAC) protocols designed for wireless sensor networks. The major sources of energy wastage are idle listening, collision, overhearing, and control packet overhead. In the previous protocol, Advertisement based MAC protocol (A-MAC) an energy-efficient and robust Intra-cluster and Inter-cluster communication protocol was proposed for large scale Wireless Sensor Networks (WSNs) and mainly focused on the communication between Cluster Head (CH) and the Base Station (BS). The communication between the CH-BS could be accomplished with traditional Medium Access Control (MAC) protocols such as Time Division Multiple Access (TDMA) or Carrier Sensing Multiple Access (CSMA). While protocols such as TDMA work well in some situations, they do not work well when the number of clusters is large and the traffic load between the CH-BS is low and they allocate a large amount of time for CH-BS communication but A-MAC is more efficient than traditional MAC protocols which lowers the delay and improves the network capacity by reducing the CH-BS communication time. In this project, a new MAC protocol for the deployment of relay nodes is proposed for maximizing the network lifetime in WSNs. Since in the A-MAC the relay node placement positions are chosen randomly an enhancement has been made in this paper such that a traffic aware scheme for the deployment of relay nodes is also included. The network simulator (NS-2) is used for the simulation. From the simulation results it is observed that the enhancement in the A-MAC protocol performs better when compared with A-MAC.

IndexTerms **- Wireless Sensor Networks (WSNs), Cluster Head (CH), Base Station (BS), sensor nodes, relay nodes.**

I. INTRODUCTION

Since the start of third millennium, wireless sensor networks (WSNs) generated an increasing interest from industrial and research perspectives. A WSN can be generally described as a network of nodes that cooperatively sense and may control the environment enabling interaction between persons or computers and the surrounding environment. As nodes in wireless sensor networks typically operate unattended with a limited power source, energy efficient operations of the nodes are very important. Although energy conservation in communication can be performed in different layers of the Transmission Control Protocol/Internet Protocol (TCP/IP) protocol suit, energy conservation at MAC layer is found to be the most effective one due to its ability to control the radio directly. Therefore, to ensure a long-lived network of wireless communicating sensors, we are in need of a MAC protocol that is able to improve energy efficiency by maximizing sleep duration, minimizing idle listening and overhearing, and eliminating hidden terminal problem or collision of packets.

Load balancing in sensor networks and an algorithm for clustering the sensor nodes around some higher-powered relay nodes, acting as cluster heads, to achieve the objective [1].A desired network lifetime is achieved using minimum total energy in a sensor network that contains relay nodes. In this model, the sensor nodes may also take part in routing. They have attempted to achieve the goal of maximizing the network lifetime by determining the optimal locations along with the optimal energy provisioning of the relay nodes within the networks [2]. A novel location relay selection scheme for alliances in which the relay nodes and the two types of relay selection schemes such as random relay selection scheme(RRS) and Location relay scheme(LRS) are explained in order to solve the collision resolution[3].

Tree MAC: Localized TDMA MAC protocol for real-time high-data-rate sensor networks was proposed and it is a TDMA-based MAC protocol designed for high data rate applications. Tree MAC assumes the traffic pattern is many-to-one, forming a tree [4].

1.1 Relay Nodes In Wireless Sensor Networks:

One category of research on sensor networks has focused on the energy-management issues after the network has been deployed, i.e. it considers that the placement of nodes is fixed by deployment, and then aims to minimize the energy consumption so that the lifetime of the network is maximized. Another category of research has focused on the placement of sensor nodes in a sensor network before its deployment. The objective of this category of research is to address the node-placement problem in sensor networks, which is to determine a set of locations for the sensor nodes within a sensor network such that, if sensor nodes are placed at these locations, the network may remain operational with the available energy resources, for a period of desired lifetime using a minimum number of nodes but ensuring high coverage of the sensed area as well as resilience to failure. In sensor networks, sensor nodes sense the environment and generate data. These data from all sensor nodes are needed to be gathered and relayed towards the base station using wireless media. Considering the transmission-energy-cost model of sensor networks, use of multi-hop path for the routing has been preferred in most of the literature. The multi-hop routing strategy has been proposed for both flat and hierarchical architectures.

1.2 The Traffic Aware Relay Node Deployment Problem

Wireless Sensor Network that consists of source nodes (or S-nodes in short) and relay nodes (or R-nodes in short) are considered. S-nodes sense the ambient environment and forward the data, through R-nodes to a remote base station for further processing. The locations of S-nodes and the base station are given according to application requirements. The data rates of S-nodes are also known, but may be different for different S-node depending on the specific type of data sensed. Given these application-specific conditions, the network lifetime thus closely depends on the geographical deployment of the R-nodes, as illustrated in Fig. 1.1.

Let $S=\{s_1,s_2\ldots\ldots s_m\}$ denote the set of locations of ' M'S-nodes and s_0 be the location of the base station. Let the data rate from s_i be γi [4]. Define traffic path $p_i=x_0,x_1\ldots\ldots\ldots x_{li}$ as a sequence of R-nodes which participate in relaying the traffic flow from si. Next the problem how to deploy a given number of R-nodes so as to maximize the network lifetime, which is defined as the lifetime of the first depleted relay node is also considered.

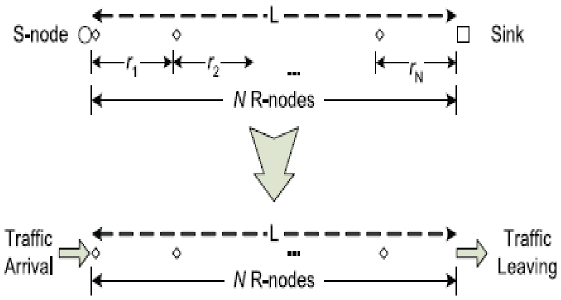

Fig.1.1 Illustration of deployment scheme for Single source and Single traffic flow.

Given N, the total number of R-nodes to be deployed, where N ⩾M, finds the geographical locations for R-nodes

$F=\{f_1,f_2,.,f_N\}$ together with their respective communication ranges $R=\{r_1,r_2,\cdots.,r_N\}$and traffic paths for S-nodes $p=\{p_1.p_2\ldots\ldots p_m\}$, so as to minimize the energy consumption of the R-nodes. Specifically, given that all the relay nodes have the same residual energy initially, the network lifetime is critically bounded by the nodes with the highest energy costs[5]. Thus, we are interested in minimizing the maximum energy consumption among the R-nodes.

$$\min \max_{1\le i\le N} \sum\nolimits_{i\varepsilon p,j=1\ldots M} \gamma j[\sum\nolimits_{recv} + \sum\nolimits_{send} r_i] \quad (1.1)$$

Equation 1.1 is considered where multiple traffic flows arrive at one location and need to be relayed to another. Given 'N'R-nodes and 'K' traffic flows, we need to decide whether to merge these flows or to relay them separately by assigning n_i R-nodes to the ith flow, as long as $\sum k_i=1$, $n_i=N$. If the traffic flows are relayed separately, the energy consumption of one R-node for the ith traffic flow is IEsingle (L,ni, γ i) for i=1,2.

$$\sum\nolimits_{single}(L,n1,\gamma 1) = \sum\nolimits_{single}(L,n2,\gamma 2) \quad (1.2)$$

The condition for assigning R-node is given by the equation 1.2. An illustration of deployment scheme for single source and two traffic flows can be shown in fig.1.2.

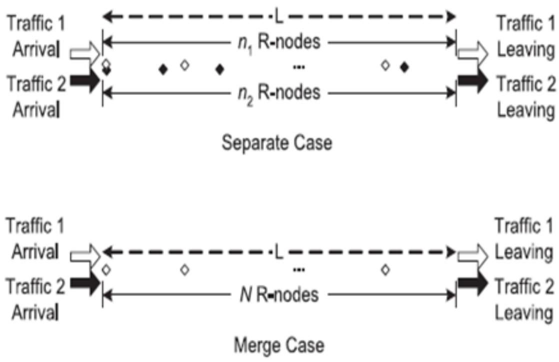

Fig 1.2 Illustration of deployment scheme for single source and two traffic flows

The energy consumption of the relay node can be given separately as shown in the equation 1.3.

$$\sum_{seperate} \approx \left(\frac{L}{N}\right)^{\alpha} \left(\sqrt[\alpha]{y_1}+\sqrt[\alpha]{y_2}\right)^{\alpha} \qquad (1.3)$$

On the other hand if the traffic flows are merged, the energy consumption of one relay node becomes as follows:

$$\sum_{Merge} = \sum_{single}(L, N, (y_1 + y_2)) \approx (y_1 + y_2) \left(\frac{L}{N}\right)^{\alpha} \qquad (1.4)$$

From equation 1.4 we come to know that by merging the two flows leads to the minimum energy cost on a relay node [6]. Suppose if multi traffic flows are considered then the optimal solution is to merge all flows in to one and apply the optimal scheme of single source with single traffic flow.

II. PROPOSED METHOD:

In this method, a new protocol (A-MAC) that incorporates a collision resolution scheme is introduced. This protocol uses collided packets to save energy and improve network throughput by deploying relay nodes around BS. (Relay nodes are only used to help resolve collisions; they do not transmit their own packets). For the CH-BS communication, all CHs send their packets to the BS at the same time; when the BS detects a collision, it asks relay nodes to transmit what the relay nodes heard (i.e., the collided packets or mixture). After the BS receives enough mixtures, the BS resolves the collision using a multiple input and multiple output algorithms. The deployment of the relay nodes has to not only ensure connectivity between the data sources and the sink, but also accommodate the heterogeneous traffic flows from different sources and the dominating many-to-one traffic pattern. Inspired by the uniqueness of such application scenarios, in this project, we present an in-depth study on the traffic-aware relay node deployment problem.

2.1 Methodology of Proposed Work

The simulator used is NS-2 Simulator. The network is considered with a group of 50 sensor nodes. The sink nodes are surrounded by a group of relay nodes. The Traffic aware relay node deployment is discussed. First a group of sensor nodes are considered with data packets of some size indicated in orange color and the next group of nodes with some other packet size in red color and the other group in blue color nodes.

Table 2.1 Simulation Parameters for Traffic Aware Relay node Deployment

Parameters	Specification
Simulation Area	200mX200m
Node Transmission Range	20m
Propagation Model	Two Way Ground Model
Traffic	CBR
Packet size	53Bytes
Number of nodes	50
Simulation Time	100
Routing protocol	AODV

Table 2.1 displayed the various parameters like simulation area, Transmission range, propagation model, traffic, packet size, number of nodes, simulation time and routing protocol and its specification for traffic aware relay node deployment using NS-2.

III.RESULTS AND EXPERIMENTS:

This section provides the analyzed results obtained after implementing the proposed methodology of traffic aware relay node deployment in the network.

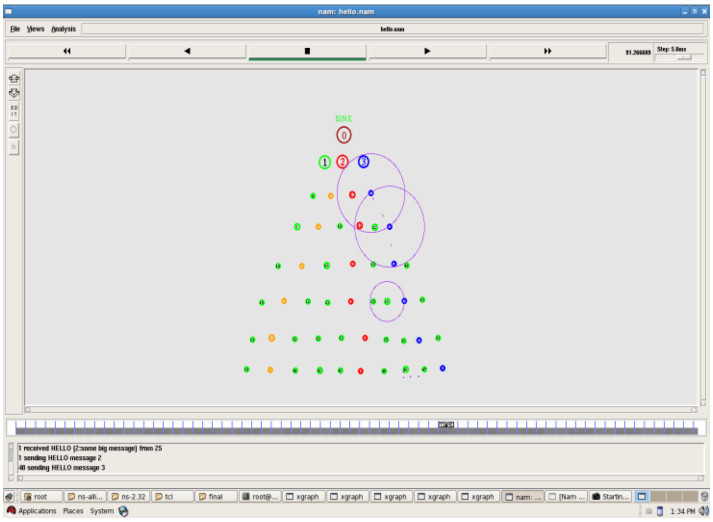

Fig 3.1Simulation Scenario for the Deployment of Relay nodes

This section provides the analyzed results obtained after implementing the proposed methodology of traffic aware relay node deployment in the network. The selection of the relay node to communicate with the sink is chosen based on various factors such as the distance which includes the transmission distance and the Euclidean distance based on the formula .The traffic aware deployment is brought in to consideration by considering the energy consumption of the nodes and selecting the relay nodes to transfer the data accordingly.

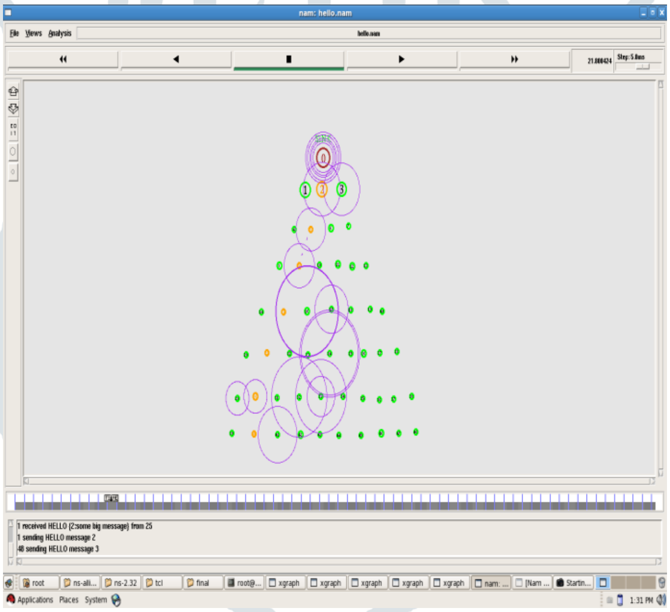

Fig 3.2 Simulation Scenario for the traffic aware relay node deployment

The performance of A-MAC is compared with that of Traffic A-MAC for various parameters such as throughput, delay, packet delivery ratio, and packet drop and energy consumption. The energy levels of the cluster heads of various clusters are compared and the graph is plotted. First the energy consumption is compared between A-MAC and traffic A-MAC.

3.1 ENERGY CONSUMPTION

From the graph given below it is inferred that the energy consumption of Traffic AMAC is better when compared to that of the AMAC.

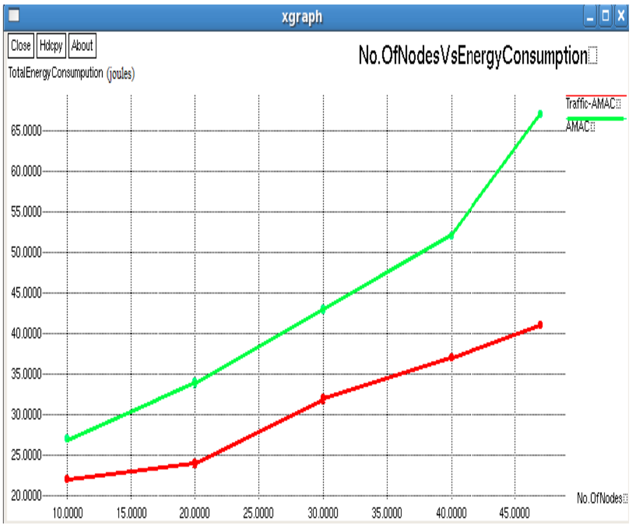

Fig 3.3 Number of nodes Vs Energy Consumption characteristics

For example when the number of nodes is ten the total energy consumption for A-MAC is twenty eight joules and Traffic A-MAC is twenty joules.

3.2 PACKETS DROPPED

In the Fig3.4 the number of nodes is taken in x axis and the packets dropped is taken in y axis in the above graph. The performance of Traffic A-MAC is better when compared to that of the A-MAC. We can see that the variation in the packets drop for Traffic A-MAC for different number of nodes is because of the congestion. When the congestion is more the drop rate gets increased.

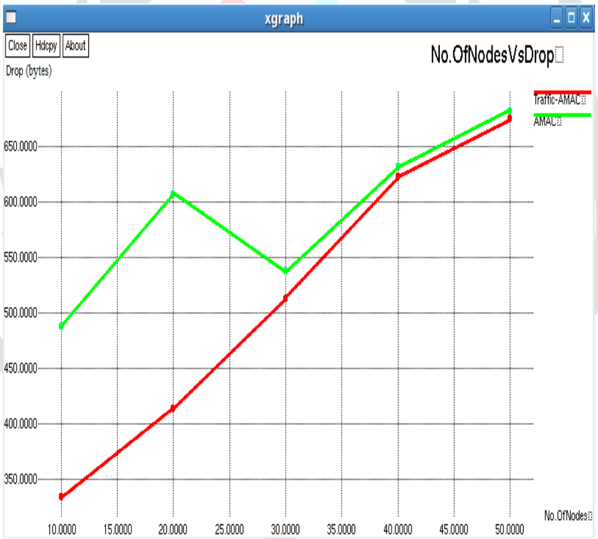

Fig 3.4 Number of nodes Vs Packets Drop characteristics.

3.3 DELAY

The graph shown in Fig3.5 compares the delay for A-MAC and Traffic A-MAC.From the graph it is inferred that the performance of Traffic A-MAC is better when compared with A-MAC.But in both the MAC we can see that when the number of nodes is increased the delay also increases since the traffic becomes more when the number of nodes are increased.

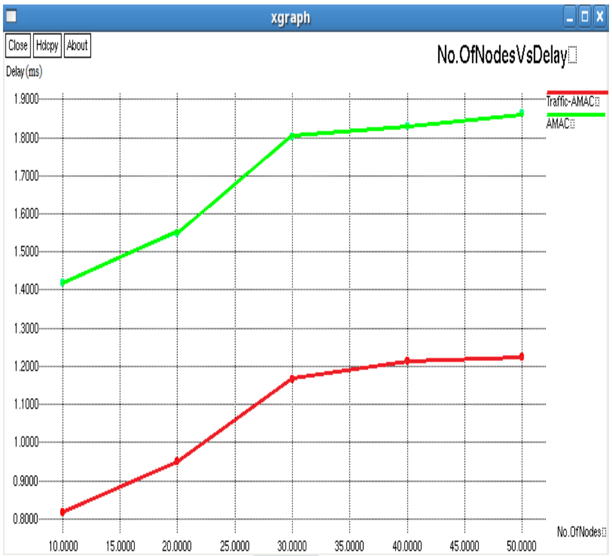

Fig 3.5 Number of nodes Vs Delay characteristics

3.4 THROUGHPUT

In this section we compare the throughput of AMAC and Traffic A-MAC. In the A-MAC the relay nodes are placed in a half cycle configuration that has sink in the center and in traffic A-MAC we also bring in to consideration about the placement of the relay nodes. We define the throughput as the percentage of the number successfully received packets to the number of packets send. From the figure it shows that traffic AMAC performs much better than A-MAC.

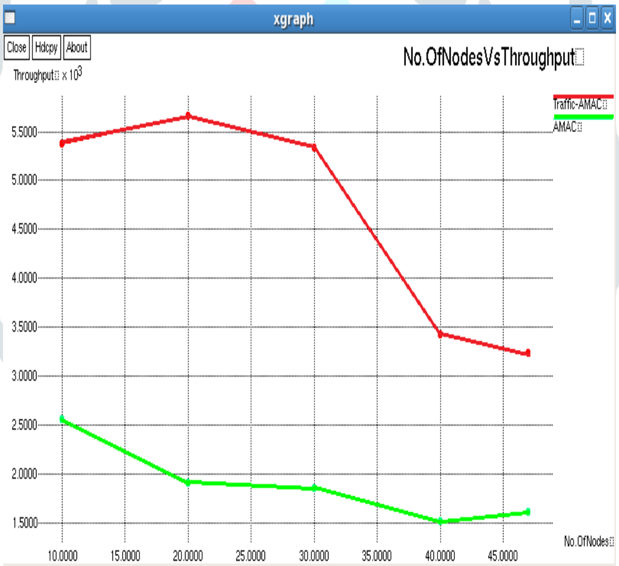

Fig 3.6 Number of nodes Vs Throughput characteristics

3.5 PACKET DELIVERY RATIO

Packet delivery ratio is computed as the long term ratio of the total number of packets reaching the destination successfully to the total number of packets send by the source.

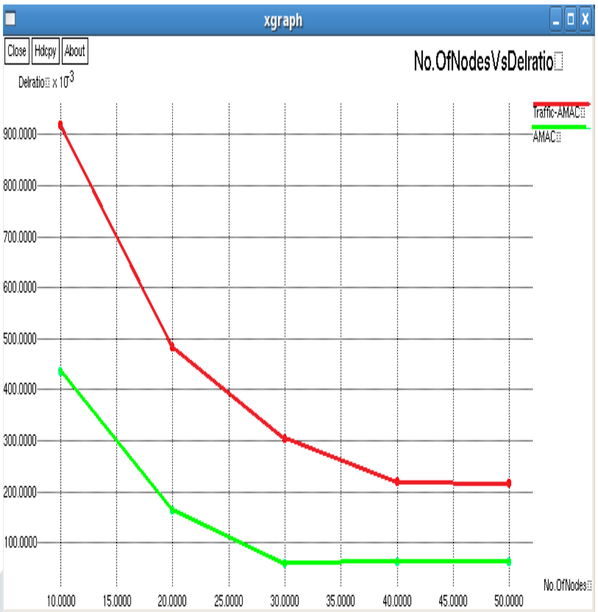

Fig 3.7 Number of nodes Vs Packet delivery ratio

From the above graph it is inferred that the packet delivery ratio is better in Traffic A-MAC when compared with that of A-MAC.

1V.CONCLUSION

Thus by using the various metrics the performance of Traffic A-MAC is better when compared to that of A-MAC and the traditional MAC protocols such as CSMA or TDMA such as throughput, delay, Energy consumption, packet delivery ratio and packets dropped. In the future scope energy sustainable relay node deployment in Wireless sensor networks and load-balanced data gathering as well as making the network fault tolerant criteria can be focused.

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