Efficient Wireless Sensor Networks for Data Aggregation

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***Abstract*— Data Aggregation is the most useful application in wireless sensor network, but efficiency of network is also very important for this purpose. Since, the sensor node has been governed by the limited and very low battery power. Our main objective of research is to reduce the power consumption in communication of data packets. Power consumption can be optimized either by using low value of transmitting power or by reducing number of retransmitting nodes, in any multihop path. An optimized sensor network has been used to reduce the power uses of sensor node power bank i.e. battery.**

Keywords—Sensor Nodes; Square Grid Network; Hexagonal Wireless Sensor Network; Node spatial density; Bit Error Rate, Wireless Sensor Networks.

I. INTRODUCTION

In wireless sensor network, packets have been transmitted from the source node to the destination sensor node, via multihop route. Packets have been relay from various intermediate sensor nodes. These relay nodes and transmitting sensor node are operated by limited and low battery power.

Although, wireless sensor network has a lot of applications, but the most important application is data aggregation from remote areas. In such application, wireless sensor nodes are densely deployed either in regular arrangement or in random manner. One thing should be kept in mind that the installation of sensor nodes is a tremendous job. Hence, the power is the main issue in wireless sensor network.

In any sensor node, power is consumed in three stages- 1) In transmission, 2) In reception of data and 3) In hold stage, But the measure part of battery power spends in the transmission of data packets. Hence, due to limited and low battery power in sensor nodes, the only way of getting high quality of services (QoS) can be achieved to reduce the number of links or hop in a route. In wireless sensor networks, the number of hopes or links can be reduced by the selection of a right arrangement of wireless sensor nodes [1]. These sensor nodes have been communicate wirelessly, hence the channel is susceptible to error. So in any data transmission, high quality of services can also be achieved by reducing the number of transmissions. As the data packets are transmitted from source sensor node to the destination or base station through multipath means data packets have been relay through various intermediate sensor nodes. In this relay process, the original information gets corrupted more and more at each intermediate sensor node. Hence, in this paper, we have reduced the number of transmissions of the data packets, which ultimately reduces the error and improves the QoS.

In this paper, we have suggested a new structural arrangement of wireless sensor network. We have compared our suggested network with the existing network in size, in number of node required, transmission time and in other fields.

We have also compared the quality of services for existing and proposed structural arrangement of wireless sensor nodes. We validate our analysis using MATLAB simulation. The rest of this paper is as following: In Section II presents sensor network model. In Section III defines the comparison of Square grid and Hexagonal Networks. Numerical results and Discussions are presented in the Section IV. Finally section V concludes the paper.

II. NETWORK MODEL

The best way to enhance the performance of a wireless sensor network, an appropriate network must be required from previous networks. Square grid topology was considered by [2], [3], [16], [17], [18]. It motivates us to discover a new topology. Hence for the enhancement of the performance, hexagonal topology is being selected for its applications and we got improved results.

Throughout this paper, we consider a special arrangement where P sensor nodes are spread over the finite surface of area S. Node spatial density (nsd) in a wireless sensor network is defined as the number of wireless sensor nodes spread in unit area. Which is represented by $\rho_S \triangleq P/S$.

The wireless sensor network surface of proposed scheme is as shown in Fig.1. In which sensor nodes are arranged on a parallelogram tile, which ultimately makes a hexagonal arrangement of sensor nodes (Fig. 2). Here we use MATLAB simulation for the precise performance evaluation. We assume a simple technique for data routing such that a message packet is relayed hop-by-hop, via nearest neighboring sensor nodes, till when it reaches the destination sensor node (Base station). We also assume that a source sensor node discovers a route before transmitting the data [4], [5], [6], [14]. Due to the similarity of the topology, the distance to the nearest sensor node, denoted by a fixed value (r_{link}) called hop and a sequence of hops is constituted a route. First observe that constructing a parallelogram lattice of P sensor nodes spread over a surface of area S is equivalent to fitting P parallelogram of area $(\sqrt{3}\, r_{link}^2)/2$ into a large parallelogram of area S.

Hence,

$$P\left(\frac{\sqrt{3}}{2}\, r_{link}^2\right) = S \qquad (1)$$

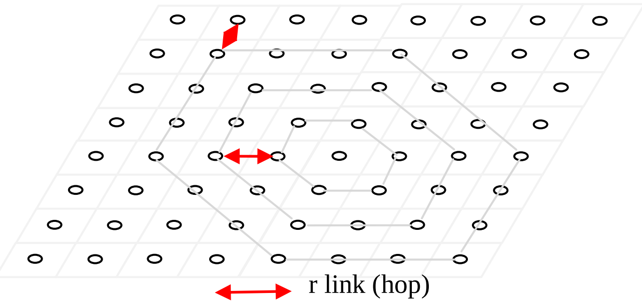

Fig. 1: Sensor Node Arrangement

and, therefore, the hop distance to the adjacent wireless sensor node can be written as following:

$$r_{link} = \sqrt{\left[\frac{S}{\left(\frac{\sqrt{3}}{2}\right)P}\right]} = \sqrt{\frac{1}{\left(\frac{\sqrt{3}}{2}\right)\rho_S}} \quad (2)$$

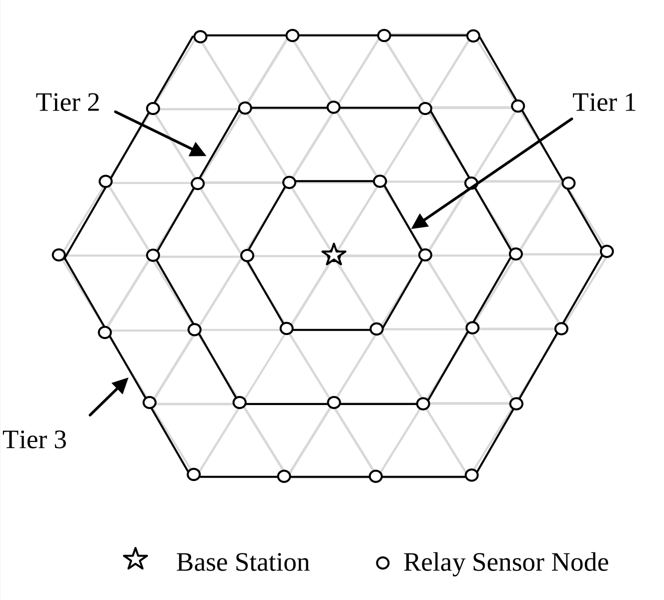

Fig. 2: Hexagonal Wireless Sensor Network

The route selection from source to the Base Station is very simple, in this process only one sensor node act as transmitter and only one sensor node act as receiver at a time. All other remaining signal received at the receiving sensor node must be treated as signal interference.

III. Quality of Servicess and Other Parameters

The Quality of Services and other parameters of Hexagonal wireless sensor network are discussed as:

A. *Bit Error Rate*

In this section, we compute the hop Bit Error Rate and the route BER (total bit error at the end of a multihop route). Generally, in wireless sensor network, the received signal observed at the receiving node is the combination of three components:

1) The original message from the transmitting wireless sensor node, 2) The interfering data from sensor nodes other than transmitting sensor node, and 3) The thermal noise generated from semiconductor components used in sensor nodes [7], [8], [9], [10].

We assume that the noise signal (interfering data), which come from other wireless sensor nodes, is the summation of individual noise signal (interfering data) come from each nodes [11], [12], [13], [15]. The received signal S_r during each bit period can be expressed as

$$S_{Received} = S_{Transmitting} + S_{Interference} + \text{Thermal Noise}$$

$$S_r = S_{signal} + \sum_{k=1}^{N-2} S_k + \omega_{thermal} \quad (3)$$

Where, S_{signal} is the original message signal from the transmitting sensor node, S_k is noise signal from k[th] interfering wireless sensor node, and $\boldsymbol{\omega}_{thermal}$ signal is called thermal noise, generated from semiconductor components used in sensor node. In Digital Communication, if we consider BPSK, the message is in the form of bits i.e. in the form of "Zero (0)" and "One (1)". When such data packet is transmitted from the transmitter, this gets corrupted means many of the "Ones" change into "Zeros" and many of the "Zeros" change into "Ones". The amount of these corrupt bits decided the received signal quality; hence the measure of these corrupt bits over total number of transmitted bit is called Bit Error Rate.

$$\text{Bit Error Rate} = \frac{\text{Total no. of received bit with error}}{\text{Total number of Transmitted Bits}} \quad (4)$$

B. *Number of Sensor Node used in Network*

Life time, data processing time, packet receiving time and many other parameters have been associated with the total number of sensor node used. In Hexagonal wireless sensor network, the number of sensor node used to design a wsn is lesser than the number used to create wsn in other topologies.

$$\text{No. of Sensor Nodes} = \left[6 \sum_{i=1}^{i_{max}} i\right] + 1 \quad (5)$$

Where, i_{max} is the maximum number tier in the wireless sensor networks.

C. *Packet Receiving Time from end tier node to the base station*

Packet receiving time is the main factor in Data Aggregation application. Hence, the value of this factor also shows the efficiency of wireless sensor network. In Hexagonal wireless sensor network it is less as compared to the existing square grid wireless sensor network. This happens because the total number of hops used for traveling the data packet from end tier node to the base station in hexagonal wireless sensor network is less than the square grid network.

IV. Comparative Results

In this section, we discuss and compare simulation results of proposed idea with existing wireless sensor network. Moreover, MATLAB is used as a simulation tool.

A. Route Bit Error Rate variations

In Fig. 3, the curve shown in Green colour represents the BER_{route} for R_b= 100Kbps in Square Grid Network, for the same data rate but in Hexagonal Network the BER_{route} is represented by Red colour for various sensor node spatial densities. Blue and Black colour curve represents the BER_{route} for Hexagonal and Square Grid Network respectively with R_b=2Mbps. It is clear that the wireless sensor network using Hexagonal Network shows the better performance than Square Grid Network.

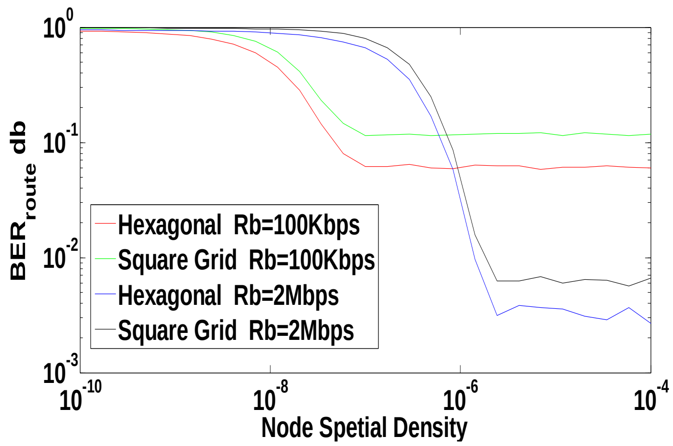

Fig. 3: Comparison between Square Grid and Hexagonal Topology on the basis of BER_{route} and Node Spatial Density for various Data Rates.

B. Sensor Node Requirement

Number of Wireless Sensor Node can also be reduced by using Hexagonal Topology, Fig. 4 shows the comparative study of number of Sensor Node required in the function of Number of Tier or Network Size.

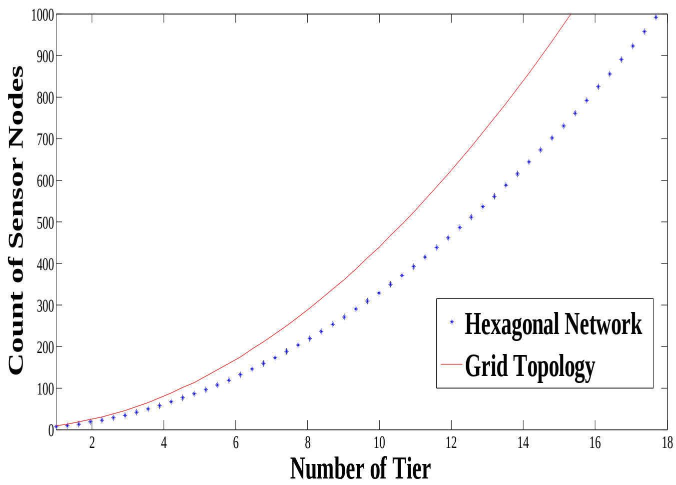

Fig. 4: Total Sensor Node required vs Number of Tier or Network Size

C. Packet Receiving Time from end of tier to the Base Station

Here we compute and compare the Receiving Time of a Packet of message bits, transmitting from the last tier to the Base Station. It is clear from Fig. 5 that the Packet arrival time from the end tier to base station for the proposed model is less than the Square Grid Topology.

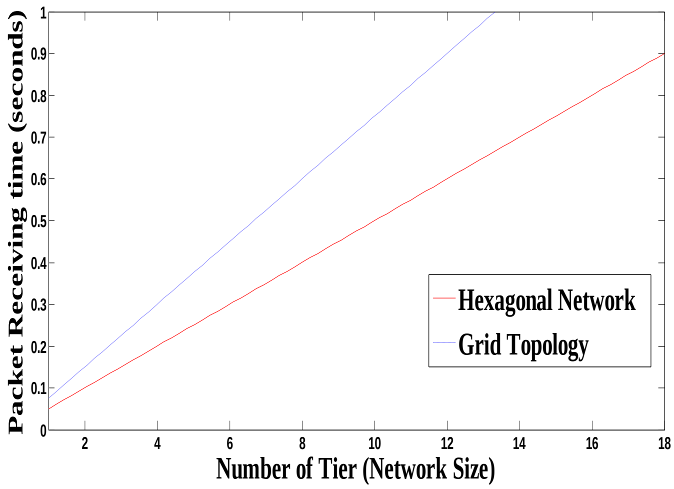

Fig. 5: Packet receiving time in the function of Number of Tier or Network Size.

D. Improvement in BER for proposed scheme (In %)

In this, we compute the bit error rate after completing a route in proposed idea. Fig. 6 shows the percent improvement in the BER_{route} of square grid topology in the function various sensor node spatial densities. Hence, it is clear that in hexagonal topology previous result can be improved up to 54 percent. The best results are shown (more than 20% Improved BER_{route}) after 10^{-8} node spatial density and outstanding improvement shows after 10^{-7}.

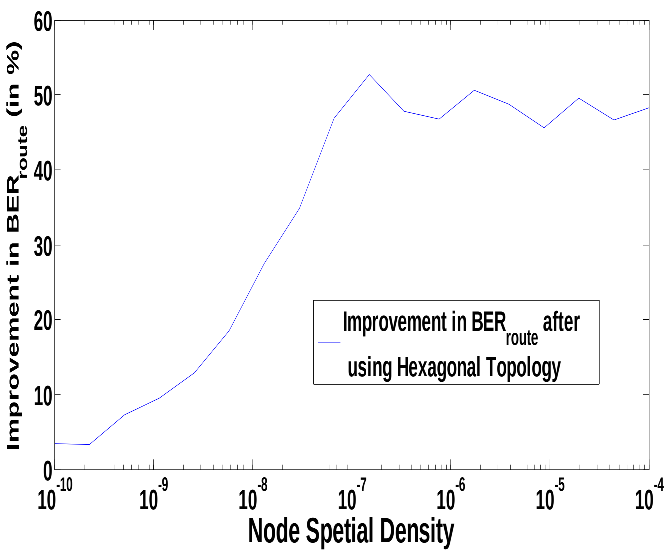

Fig. 6: Percentage Improvement in BER_{route} after using hexagonal topology in the function of Node Spatial Density.

V. CONCLUSIONS

The Hexagonal wireless sensor network improves the quality of services as compared to Square Grid Topology and also provides better connectivity of data due to less involvement of noise. Some other parameters also show that the performance of Wireless Sensor Networks enhances using Hexagonal Topology.

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