Prolonging Network Lifetime using Hexagonal Layered Structure in ML-MAC Protocol

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***Abstract*— Deployment of sensor nodes in proper way is one of the most effective methods to increase the life time of a wireless sensor network and also better utilization of coverage area. A wireless sensor network is a group of sensor nodes which are used to monitor a specific area in which they are deployed. Node deployment is also an issue on which the desire information is dependent. A proper node deployment scheme not only reduces the network cost but also increase the lifetime of network. In this paper ML-MAC is used to minimize the consumption of energy and hexagonal layered scheme is used to maximize the coverage of sensing area. A new deployment scheme is proposed in which nodes are deployed in hexagonal layers. Simulation results show that proposed pattern uses fewer nodes and provides better coverage and throughput than random deployment. In addition to this it is an energy saver which provides minimum delay as compared to random deployment.**

Keywords*— *Wireless sensor networks (WSNs), Node deployment, ML-MAC, qualnet 6.1, Coverage, throughput and Energy Efficiency

I. Introduction

Wireless Sensor Networks (WSNs) [8] consist of a large number of sensor nodes, deployed over an area to collaboratively monitor or sample data from physical [5] or environmental phenomenon and send data to other base stations through wireless link. Node deployment can be random or deterministic in nature. In WSN nodes are in form of clusters and networks that performs a specific monitoring task without any human interference and resolutions. Sensor nodes are able to sense physical environmental information and process the acquired data both at unit and cluster level and send the result to the cluster and other base stations. Transceiver has four operational modes such as sleep, idle, receive, and send [6]. In sleep mode the nodes can listen to data frames. This is called as listening stage of sleep mode. When nodes listen to data frame it will shifts to active mode else it remains in sleep mode. In active mode the data is transmitted normally. Communication devices are in active state and are able to send or receive data. Dormant Mode is also one of the sleep modes in which sensor nodes are on low-power mode and remain in this mode for agreed amount of time after that nodes can be in active mode. When sensor nodes go back to active mode from dormant mode, they again rediscover networks and start exchanging data. Power Unit is the most important part of the sensor node. Power consumption by a sensor network defines the lifetime of the same.

However, node deployment is a major issue which is to be solved as a proper node deployment scheme [13] reduces the delay as well as cost of the network. With the increase in coverage, network lifetime also increases. Hexagonal tiling structure is described in [9] and [10]. As sensor nodes have limited energy ,so the lifetime is affected by the consumption of energy. Here, the nodes are deployed in such a way that it forms multiple layers of hexagons. All these hexagons are concentric. In this paper ML-MAC protocol is to minimize energy consumption which increases the lifetime of network.

This paper is organized as follows: Section II. illustrates the related work in this area where with multilayering, highly energy efficient network was achieved. Section III shows simulation scenario wherein where we have discussed our proposed plan of hexagonal deployment of nodes in the network which prove to be an egde ahead of random deployment. Section III. discusses the results obtained by hexagonal deployment of nodes. We have compared our results with random deployment and proved through extensive simulation that the way in which nodes are deployed in the network affects the performance of the network Finally we conclude our paper in section IV.

II. Related Works

The existing work is mostly done using random deployment [11, 12] of sensor nodes and without using ML-MAC protocol. Manish Kumar Jha *et al.* [1] proposed a multi-layer MAC (ML-MAC) protocol which reduces node power consumption. ML-MAC is a distributed contention-based MAC protocol where nodes discover their neighbor nodes based on their radio signal level. It is a self-organizing MAC protocol and there is no need central node to control the operations of the nodes. Nodes are randomly distributed among a set of layer. ML-MAC protocol was simulated using MATLAB to compare results with other MAC protocols which were proposed for wireless sensor networks. Ranjana Thalore *et al.* [2] an energy-efficient multi-layer MAC (ML-MAC) simulated in Qualnet 5.2. This protocol was designed to achieve low duty cycle , prolonged network lifetime and low number of collisions. Ruiying Li *et al.* [14] focuses on homogeneous structured WSN with a circular target area and a base station in the center. They concluded that the number of sensor nodes needed in uniform deployment of nodes is much less than in non uniform deployment of nodes.

III. Simulation Scenario

The simulations have been done using QualNet version 6.1 software that facilitates scalable simulations of WSN. In the scenario, there are 240 nodes distributed in two different deployment schemes that is random and hexagonal. The terrain area is taken as 100m×100m. The scenario is simulated for 1500s.The traffic type used is TRAF-GEN. The scenario has one PAN coordinator where all the data gets collected from different nodes (RFDs). The packet size used is 40 bytes and message inter-arrival time is 1s.

In each scenario the nodes are divided into three layers, one third of all nodes are included in one layer and it communicates for one third of simulation time. When one layer is communicating, other layers remain in sleep mode. which is done by changing start time and stop time.

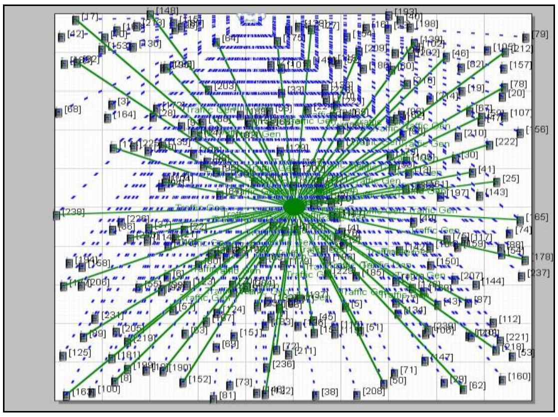

Figure 1. Random deployment

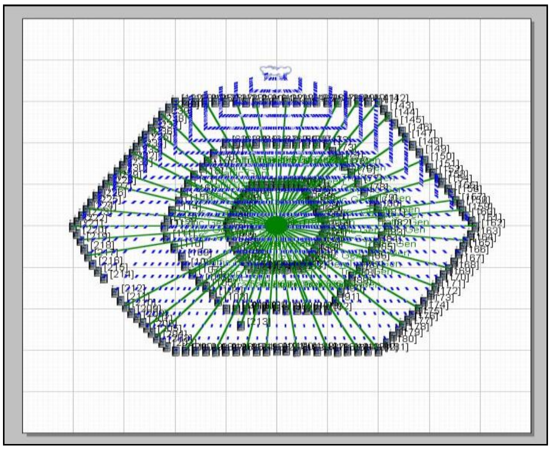

Figure 2. Hexagonal layered deployment

In Figure 1. We have deployed 240 nodes in a random fashion.We have taken 1 as the PAN coordinator. Figure 2. The hexagonal layered structure of the corresponding number of nodes.

IV. Analysis of Results

In this scenario we simulate the results using Qualnet 6.1 for 240 nodes which are deployed in random scheme and other in hexagonal layered scheme. The results are evaluated in terms of throughput, jitter, end-to-delay, packets dropped and network lifetime.

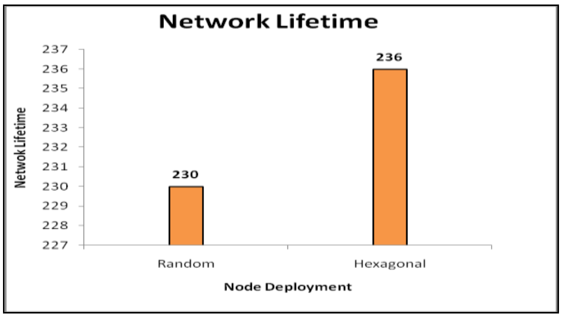

Fig 3. Network Lifetime

Network lifetime is defined in terms of days. It is defined as the surviving time of node in network. It is calculated using the residual battery capacity. Figure 3 shows the network lifetime of the simulated scenario.

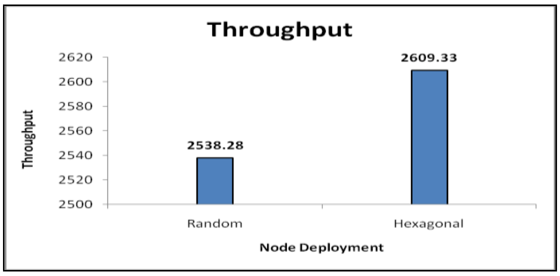

Figure 4. Throughput

Throughput of a network is defined as fraction of channel capacity which is used for useful data transmission. Figure 4 shows the throughput of the network.

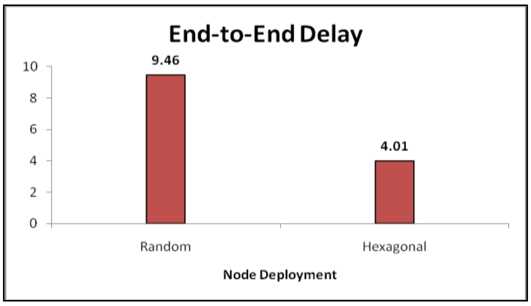

Figure 5. End-to-End Delay

The duration between the data packet generation time and the last bit arrival time at the destination is termed as End-to-End delay. It is shown in Figure 5.

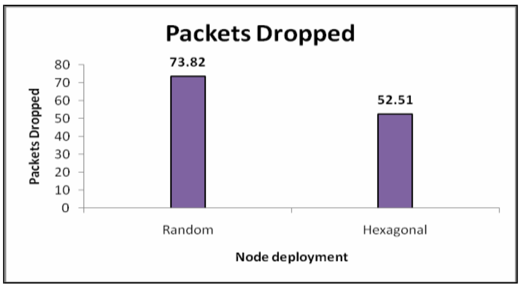

Figure 6 Packets Dropped

Number of packets dropped during network simulation are shown in figure 6.

V. CONCLUSION

The simulation results are found better in case of hexagonal layered deployed nodes as compared to randomly deployed nodes. The results are evaluated in terms of throughput, end-to-end delay, jitter, packets dropped and network lifetime. Packets are more delayed in random deployment. overall we can say that if nodes are manually deployed in hexagonal layered form, that scenario will provide better data as only the desired area is covered through this scheme. The performance of the networks proves to be edge over the random deployment in terms of network lifetime that was increased by an amount of several days and throughput which is also better. End-to-End delay and Jitter are 50% less in the hexagonal layered scheme.

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