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Investigation of Hierarchy-Based Multipath Routing Protocol

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Abstract: A WSN (Wireless Sensor Network) is a collection of a large number of wirelessly connected tiny nodes with sensing and limited computational capabilities. The main constraint on the implementation of a wireless sensor network is energy of the nodes i.e. battery life of the nodes. The sensor nodes consume energy for sensing, computations and communications purposes. The routing protocols for WSNs are designed to minimize the energy consumption of nodes in act of communication. Such a routing protocol is HMRP (Hierarchy-Based Multipath Routing Protocol). This paper provides an investigation of HMRP and gives its comparison to LEACH and PEGASIS routing protocols.

Keywords: Wireless Sensor Network, HMRP, WSN routing protocols, Performance comparison of LEACH, PEGASIS and HMRP.

I. INTRODUCTION

Wireless Sensor Network is one of the main topics of research interest in computer science community. This topic is being valued for its numerous and vast areas of practical applications. Some of these applications areas are border surveillance, civil structure monitoring, target tracking and monitoring, patient health monitoring [1-4]. A Wireless Sensor Network (WSN) can be described as a huge group of tiny sensor nodes with some computational capabilities, these sensor nodes are connected wirelessly. Each sensor node senses the respective physical, chemical or biological quantities such as temperature, pressure, nuclear radiation, heart rate etc. If necessary, this sensing data is processed locally on the node and now it is ready to be sent over the WSN. This processed sensing data is sent to the base station for record and further processing.

The base station offers link to the user for interaction with the data collected. A WSN follows a particular routing protocol to ensure the uninterrupted communication process. There are a number of constraints on the implementation of WSNs such as saturation in hardware miniaturization, security issues, limited energy etc. Out of these constraints the main focus is on the energy constraint. It is due to the fact that the number of sensor nodes in the WSNs is huge and it is practically impossible to replace the energy source of each and every sensor node. Therefore the main issue is to develop an energy-efficient routing protocol. There are some routing protocols proposed by various researchers e.g. SPIN, LEACH, and PEGASIS etc. Ying-Hong Wang et. al [5] proposes such an routing protocol called HMRP (i.e. Hierarchy-based Multipath Routing Protocol). This routing protocol offers a way to communicate in WSN energy efficiently. This paper investigates and provides a comparison to the two already present routing protocols i.e. LEACH [6] and PEGASIS [7]. The results stated in this paper shows that new proposed routing protocol i.e. HMRP is better than the already existing LEACH and PEGASIS.

II. CLASSIFICATION OF ROUTING PROTOCOLS

There are numerous routing protocols for WSNs. These routing protocols can be classified under two categories [8]:

a. Based on the network structure and
b. Based on the operation method

Network structure based routing protocols are further classified as Flat, Hierarchical and location based routing protocols.

Operation method based routing protocols are sub divided into multipath, query based, coherent based, QoS Based and negotiation based routing protocols.

The routing protocols under this study are LEACH, PEGASIS and HMRP. LEACH is a hierarchy-based routing protocol, while PEGASIS is an improvement to the LEACH routing protocol and HMRP is a hierarchy-based multipath routing protocol. The next section gives a comparison to the various types of routing mechanisms.

III. FLAT VS HIERARCHY-BASED ROUTING PROTOCOLS

In flat routing protocols the information is distributed to all the available nodes which are capable of receiving information. There is no organisation of the network or the traffic; here the best route is determined by hop by hop traversal to the destination by any path.

In hierarchy based routing protocols the nodes are grouped into a number of clusters. This grouping into clusters provides a way to organise the WSN which results into the faster and efficient working.

It can be explained by the example given here:

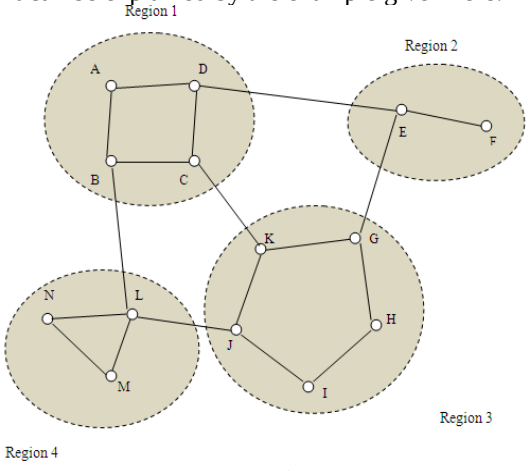

Figure 1. An example of hierarchy-based WSN

Corresponding routing information is displayed in the table 1 here:

Table 1. Routing information for example in figure 1.

Destination	Path Through	Width
A	--	--
B	B	1
C	B	2
D	D	1
Region 2	D	2
Region 3	B	3
Region 4	B	2

If the same network is used as flat network structure, the routing table would be at least double in size. And as the size of the network increases the situation would become worse and worst.

IV. REASON FOR USING MULTIPATH ROUTING PROTOCOLS

Multipath routing protocols provides efficient communication because of the following reasons:

a. The objective of using multipath routing is to achieve load balancing in WSNs.
b. A large burst of data can be split into several small buffers, so that the limited buffers at intermediate nodes do not overflow.
c. The communication channel being used may or may not allow high data rate for the whole time. Using multipath routing the effective data rate for all paths decrease.

V. MECHANISMS BEHIND LEACH, PEGASIS AND HMRP

W. Heinzelman, et al. [6] introduced a hierarchical clustering algorithm for sensor networks, known as Low-Energy Adaptive Clustering Hierarchy (LEACH). LEACH is a hierarchy-based protocol that applies randomized rotation of the cluster heads to distribute the energy load evenly among the sensor nodes in the network. The operation of LEACH is organized in rounds, each consisting of a set-up phase and a steady-state phase. During the set-up phase, the network is separated into clusters, each with a randomly selected cluster head from nodes in a cluster. During the steady-state phase, the cluster heads gather data from nodes within their clusters respectively, and fuse the data before forwarding them directly to the sink. LEACH provides sensor networks with many good features, such as clustering-based, localized coordination and randomized rotation of cluster-heads, but expends much energy in cluster heads when directly forwarding data packets to the sink.

The protocol, Power Efficient Gathering in Sensor Information Systems (PEGASIS) [7], assumes that all nodes have location information about all other nodes, and that each can send data directly to the base station. Hence, the chain of PEGASIS is constructed easily using a greedy algorithm based on LEACH. Each node transmits to and receives from only one of its neighbors. In each round, nodes take turns to be the leader on the chain path to send the aggregated data to the sink. To locate the closest neighbor node in PEGASIS, each node adopts the signal strength to measure the distance of all neighbor nodes. However, the global information of the network known by each sensor node does not scale well and is not easy to obtain.

HMRP is based on the hierarchical network structure, where the sink nodes act as root nodes. HMRP implementation mechanism comprises of two phases, Layer Construction Phase and Data Dissemination Phase. Layer construction phase is responsible for the constructing the network structure and the Data dissemination phase has the main responsibility of the communication. HMRP uses multipath data forwarding, not the fixed path. Therefore the energy consumption is distributed among various nodes resulting in the prolonged lifetime of the WSN.

VI. SIMULATION RESULTS

The simulation results for these routing protocols are given here in form of graphs:

Performance graphs for LEACH:

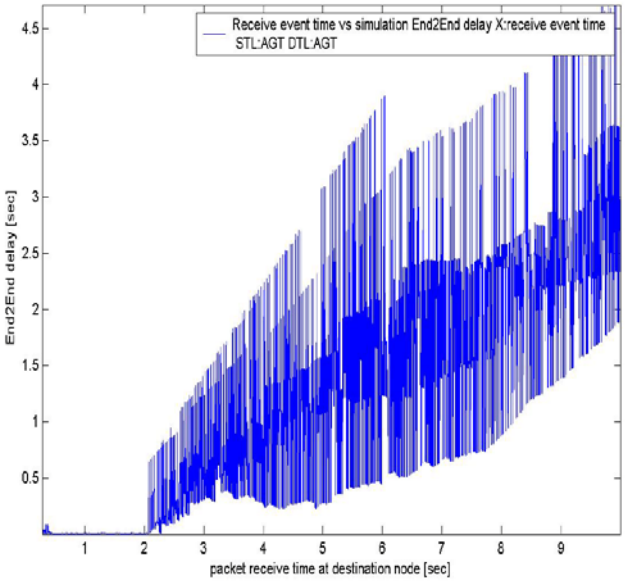

Figure 2. WSN end to end delay vs. packet receive time for LEACH routing protocol.

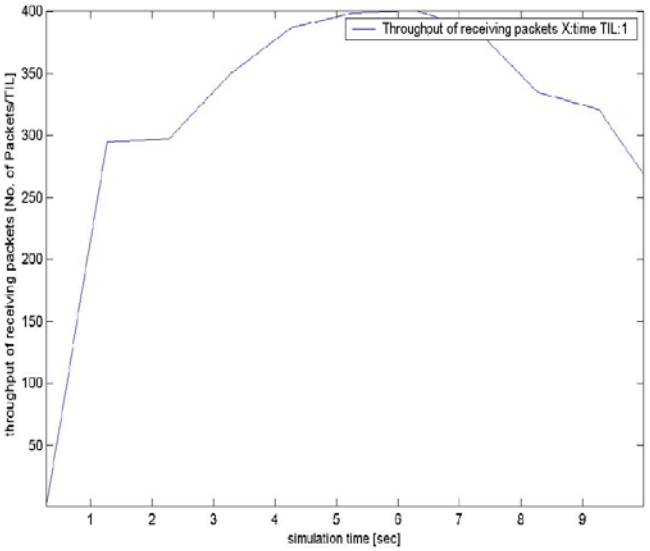

Figure 3.WSN throughput using LEACH routing protocol. Performance graphs for PEGASIS:

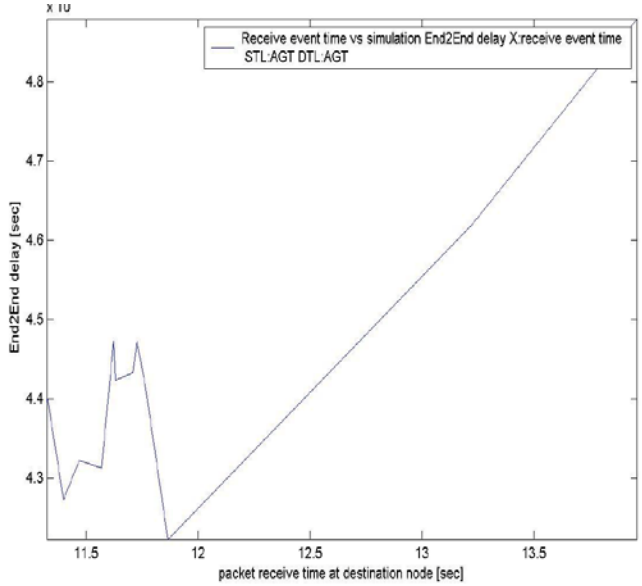

Figure 4. End to end delay vs packet receive time of PEGASIS protocol.

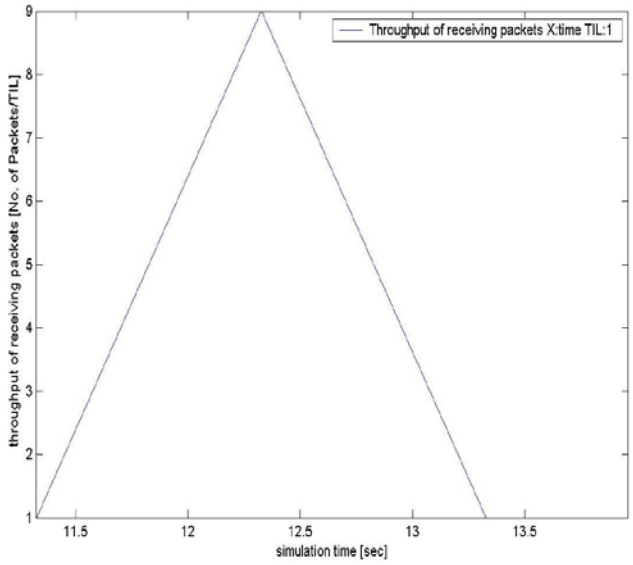

Figure 5. WSN throughput using PEGASIS routing protocol

Performance graphs of HMRP:

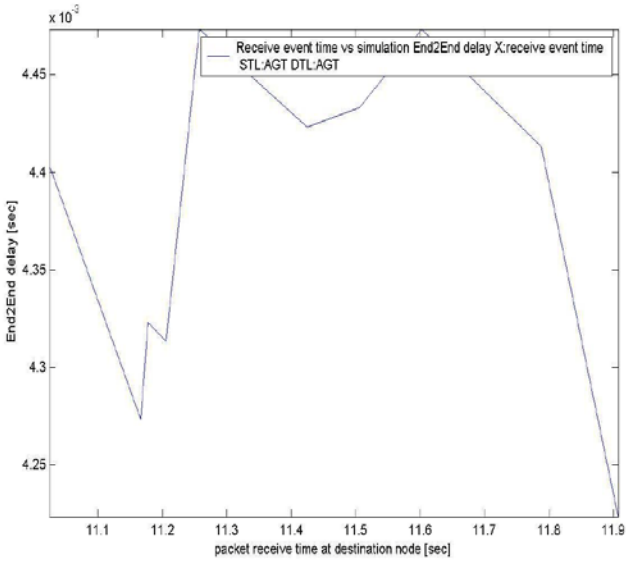

Figure 6. End to end delay vs packet receive time for the HMRP routing protocol

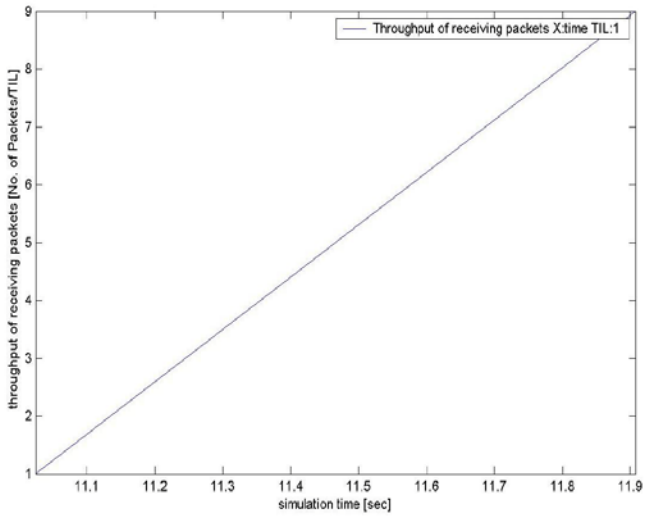

Figure 7. WSN throughput for HMRP Performance Comparison of HMRP, PEGASIS and LEACH:

On the basis of the results of the simulation, these comparison graphs are prepared

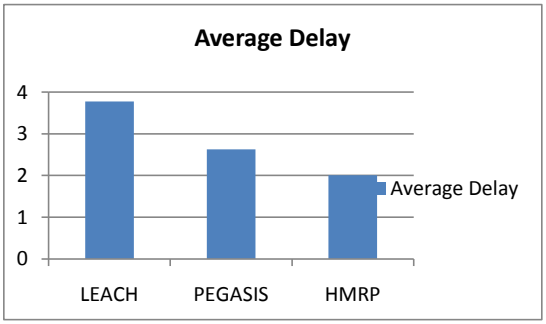

Figure 8. Average End to end delay comparison

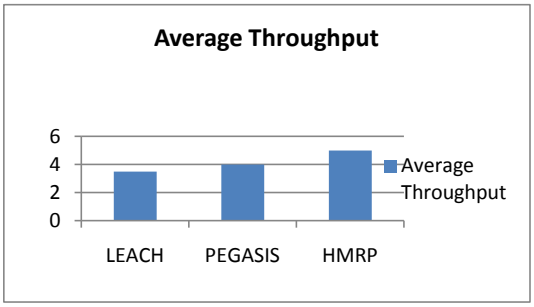

Figure 9. Average Throughput Comparison

VII. CONCLUSION

The wireless sensor networks are enabling us implement to the applications which were not possible practically before the rise of WSNs. Now as the various researches performed and new standard set out for the wireless sensor networks which are with features of low power consumptions, enhanced network lifetime etc. with more developments continuously going on this area. Hence the wider use of WSN in various real time applications is presented here. In this proposed work, we three routing protocols (LEACH, PEGASIS and HMRP) are simulated and analysed with the different performance metrics such as

network throughput and delay with the new proposed energy efficient routing algorithm called as HMRP. Most important concern for the sensor networks is the constrained energy resources. Network load distribution directly affects the sensor network system lifetime. In this research the main aim was to investigate the performance of new HMRP protocol as compare to LEACH and PEGASIS routing protocols and claims that the new proposed protocol is more better in energy consumptions and hence enhancing the network lifetime as compared to the those two existing protocols. HMRP is actually minimizing the system path loading mechanism by dividing consumption of energy in between the available nodes. Whole path is not maintained by the sensor nodes of HMRP networks, hence resulted into the less energy consumption. This simulation study shows that HMRP is performed better as compare to the PEGASIS and LEACH protocols and giving the better system throughput by minimizing the end to end delay.

A. Future Work:

For the future work, we can work on the HMRP with the improved security mechanisms which will take the less energy consumption of nodes. For achieving this goal, rather than using the currently existing security mechanisms, we have to work on the new security algorithm which will increase the sensor network lifetime by maintaining high level of security against the various kinds of attacks.

VIII. REFERENCES

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