PERFORMANCE ANALYSIS OF HEIRARCHICAL ROUTING PROTOCOL IN WIRELESS SENSOR NETWORK

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ABSTRACT

The Wireless Sensor Network (WSN) is a wireless network which consists of number of small nodes with sensing, computing and wireless communication capabilities. Usefulness of WSN can be realized from the fact that it is widely used these days to monitor activities and report events, such as fire, overheating, environmental conditions etc. in a certain area. Many protocols have been designed due to recent advancement in wireless sensor network. These protocols are used to lower energy consumption. Thus development of an energy efficient routing protocol has interested researchers. There are many hierarchical routing protocols among them author simulated leach protocol via ns2 and analyze the performance in terms of rounds, throughput and data sent to the base station.

Keywords: LEACH, Wireless Sensor Networks, NS2, Sensor Node Energy

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Introduction

A wireless sensor network (WSN) may be defined as a collection of sensor nodes that usually derive their energy from attached batteries **Bilal Abu Bakr and Leszek T. Lilien, 2014** .The sensor node is smart which can communicate in between or to the externally located base station. Wireless sensor networks are used for several applications such as traffic monitoring, surveillance, acoustic and seismic detection, environmental monitoring, etc **Salim el Khediri et al., 2014.** Wireless sensor network provides a large range of potential application to industry, Science, civil infrastructure and security.

WSN lifetime is the key characteristics for the evaluation of sensor networks. In WSN the main concern is how we can save energy of the sensor nodes. For this there are so many algorithms and routing techniques are developed to save the sensor node energy as much as possible to increase the lifetime of the networks. It is impossible that all the nodes directly communicate to the base station because of stringent constraints **Geetha.V. et al.,2012.** and nature of radio communication. As we discussed before, in WSN energy is the main constraint if communication is hop by hop then there is a lot of energy wasted which drastically reduce the life time of the network. To overcome this problem clustering algorithm is introduced which creates a balance among the key factors of the WSN node operation simultaneously. Clustering is defined as the process of selecting one node from the group of node to act as a servicing node for the neighbor nodes. Hierarchical routing is required when the size of the WSN increases for example if the application has thousands of nodes then it is preferable to have a three level or four level hierarchy so that the lifetime of the network increases.

The challenges that wireless sensor network have

- Energy Efficiency
- Responsiveness
- Robustness
- Self-Configuration and Adaptation

Related Work

Routing is a process of selecting a path through which data can be transmitted in the network from source to destination. Protocols such as LEACH, HEED, PEGASIS, TEEN and APTEEN are the hierarchical routing protocols used to route the data from node to base station.

Sensor nodes organize themselves into clusters and each cluster has at least one cluster head which act as a leader of the cluster. In this Network where low energy nodes sends the collected information to the cluster head after collecting the information from the nodes the cluster head remove the redundant information and then send data to the base station which increases the life time of the network .the process of clustering in routing provides an efficient technique to increase the life time of the network by rotating the role of the cluster head.

LEACH

Low energy adaptive routing protocol **Wendi Rabiner Heinzelman et al., 2000.** introduced by W. Heinzelman is a hierarchical routing protocol in which nodes transit the collected data to the cluster head and then cluster head compresses this data by eliminating redundancy and then send this data to the base station. Leach protocol works in rounds. In each round Leach protocol chooses the cluster head. The network model of leach is shown in figure 1 as shown in network model that all the nodes directly communicate with the cluster head and the cluster head is then directly communicated with the base station. Leach uses hop to hop communication means all nodes within the cluster should directly communicate with the cluster head. It uses an algorithm for selecting the cluster head.

Two phases are in LEACH protocol which is (i) the cluster formation and (ii) data receiving and transmission phase and round as defined the time slot gap between two phases **Raju Dutta et al., 2013.** In the cluster formation phase the process of cluster header selection is that the sensor node generates a random number between 0 and 1, If it is less then threshold T (n), it will selected as a cluster header, and report to the other nodes.

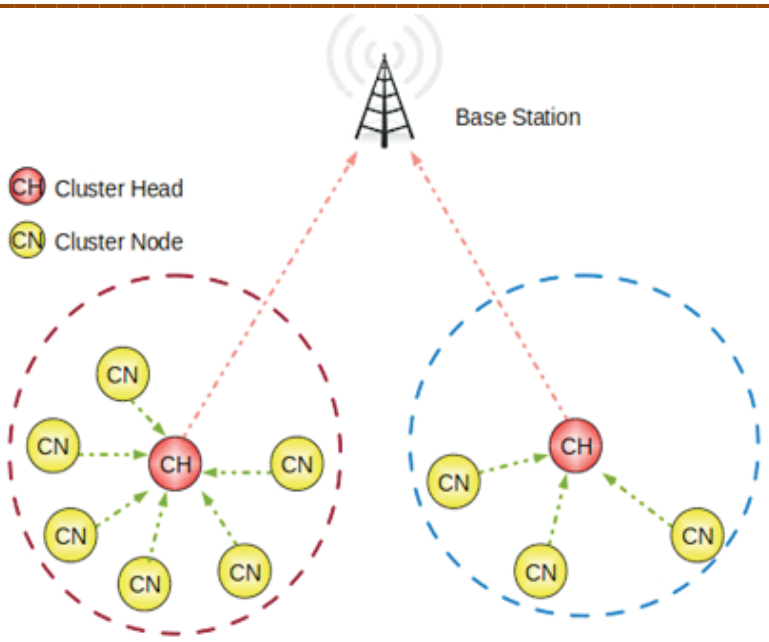


Figure 1: Network Model of LEACH D.Suresh and K.Selvakumar, 2014

The T (n) equation is as following **Jianguo Shan et al.**, **2013**

$$T_n = \begin{cases} 0 \; if \; n \notin G \\ \dfrac{P}{1-P(r \bmod (\frac{1}{P}))} \end{cases} \text{for all n belongs to G}$$

r is the current round, *p* is the probability to become the cluster header, and *G* is the number of nodes that were not cluster headers in (*r*-1) round. *N* is the total number of nodes, *k* is the expected number of cluster headers, then $p = k/N$ .This algorithm can make each sensor node become the cluster header each once, if one node is cluster header in the round, it will not be in the next round.

The Work Process of Leach Protocol

Leach works in rounds and the round begins with the setup phase, where clusters have been organized followed by steady state phase where data is send to the base station. To reduce the overhead the steady state phase is longer compared to setup phase.

Cluster Establishment Phase: after selecting the cluster head, Mac protocol is used to broadcast the ADV news to all nodes.ADV news includes node ID and packet header used as a identifying

news type **LiTian et al., 2012**.the node receives a signal and according to the signal strength it decides to join the cluster for this it uses MAC protocol to send a request (JOIN-REQ) to the corresponding cluster header. The JOIN-REQ includes node ID, cluster header ID and packet header **LiTian et al., 2012**. After cluster has been organized it creates a TDMA schedule based on the number of nodes belongs to the cluster and broadcast this TDMA schedule to all the nodes within the cluster t when to transmit the data according to their time slot. The TDMA mechanism efficiently transmits the data within the cluster and avoids the conflict during communication in the cluster.

Data Transmission Phase: After cluster has been organized and TDMA schedule is set, data transmission can start. This phase lasts a long time in the wireless sensor network. In this phase assuming all nodes have data to send but the nodes send their data according to the given time slot after sending the data the nodes will go into sleep and wait for his turn but receiver of the cluster header keep open so that it can receive the data which is send by its member at any time. Communication within the cluster would inescapably affect the others. To avoid this CDMA is used. When a node becomes cluster head it will choose a code and then send a code with the TDMA schedule. So the communication within the cluster cannot affect. After collecting all data from the member nodes the cluster head fuses all data and compresses this data by eliminating correlated data and send it to the base station. The work process of Leach protocol is shown in figure above.

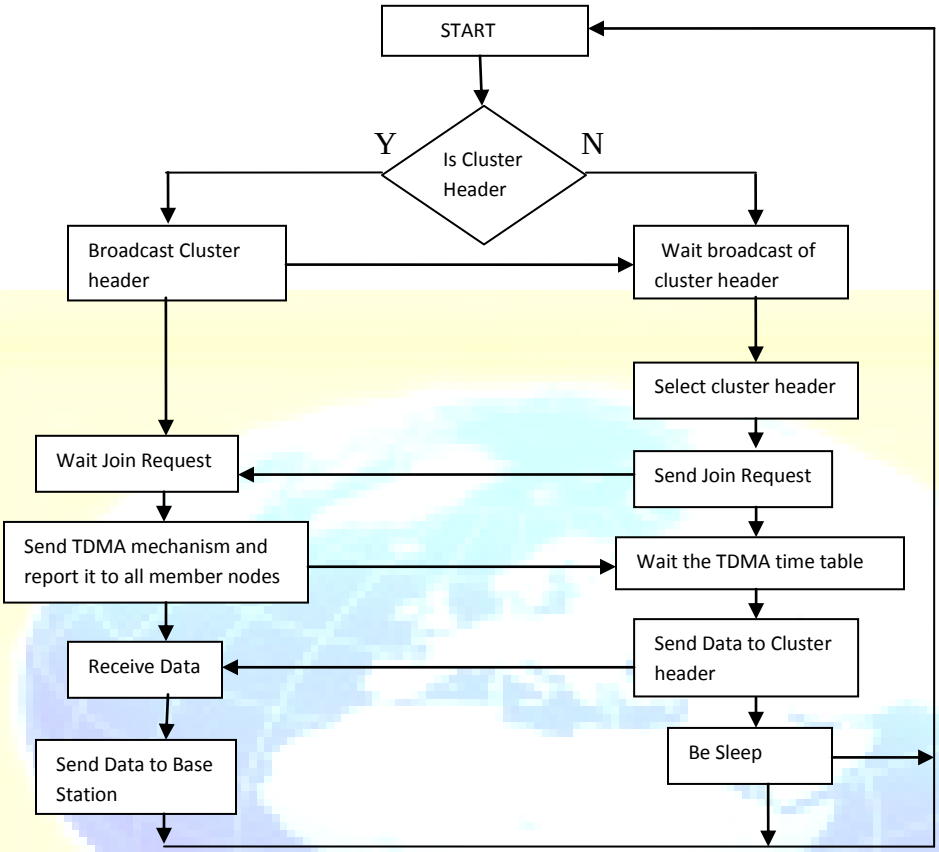


Figure 2: The work process of LEACH protocol LiTian et al.,2012

The Simulation and Analysis of Leach Protocol

Results of the simulation are presented in Table 2, Table 3, Table 4 and Table 5. Table 2 shows the data sent to the base station with respect to time at 2 Joule energy which lasts up to 2580s. Table 3 shows the data sent to the base station for 4 Joule energy which lasts up to 2720s. Table 4 shows the throughput at different no. of nodes and at different energy. Table 5 shows the life of the network in terms of rounds on different no. of nodes and at different initial energy. Figure 3 and Figure 4 shows the data sent to the base station with respect to time at 2 Joule and 4 Joule energy respectively. Figure 5 shows the life of the network in terms of rounds with respect to nodes at 2 Joule and 4 Joule energy.

Table 1: Simulation parameters

Sl. No	Item Description Specification	Item Description Values
1	Simulation Area(m*m)	100*100
2	No of Nodes	5,10,15,20
3	Channel	Wireless Channel
4	Propagation	Two Ray Ground
5	Netif	Phy/wireless phy
6	Mac	Mac/802_11
7	Protocol	Leach
8	Ifq	Queue/Drop Tail/PriQueue
9	Ll	LL
10	Antenna	Omni Antenna

Table 2: Time - Data send to base station (2 Joule)

Time(s)	5 nodes	10 nodes	15 nodes	20 nodes
500	11916000	12124000	13320000	15660000
1000	15428000	15868000	17836000	24892000
1500	16412000	16960000	19260000	30264000
2000	16632000	17220000	19644000	32560000
2140	16660000	17248000	19672000	32828000
2220		17264000	19688000	32936000
2280			19700000	32996000
2580				33148000

Table 3: Time - Data send to base station (4 Joule)

Time(s)	5 nodes	10 nodes	15 nodes	20 nodes
500	23624000	24024000	26472000	30876000
1000	30920000	31796000	35884000	49580000
1500	33044000	34156000	38900000	60512000
2000	33608000	34812000	39780000	65236000
2440	33720000	34960000	39960000	66452000
2540		34980000	39980000	66556000
2560			39984000	66572000
2720				66632000

Table 4: Nodes- Throughput

Nodes	2 Joule	4 Joule
5	150898.16	152203.16
10	629400.25	639821.84
15	1443217.13	1446801.58
20	1840826.65	1843644.80

Table 5: Nodes - Rounds

Nodes	2 Joule	4 Joule
5	107	122
10	111	127
15	114	128
20	125	136

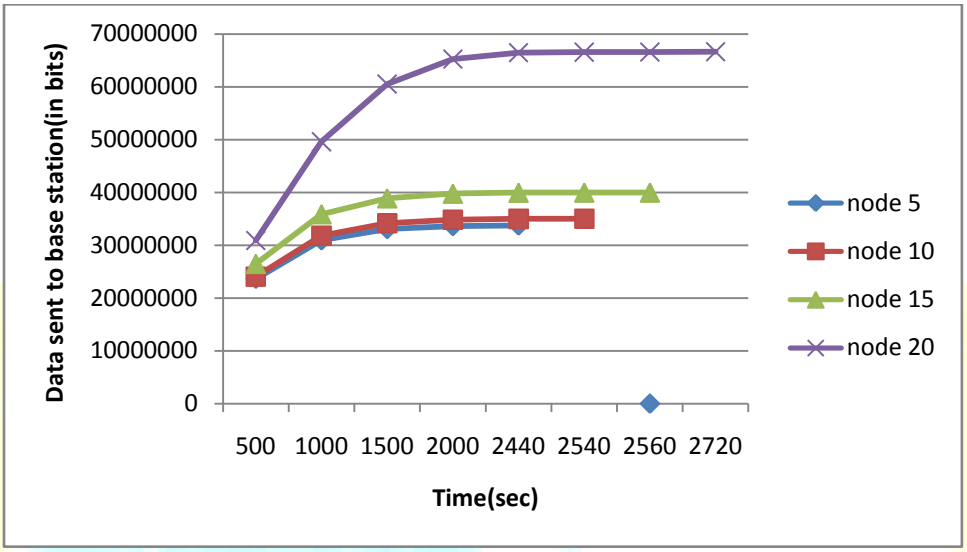
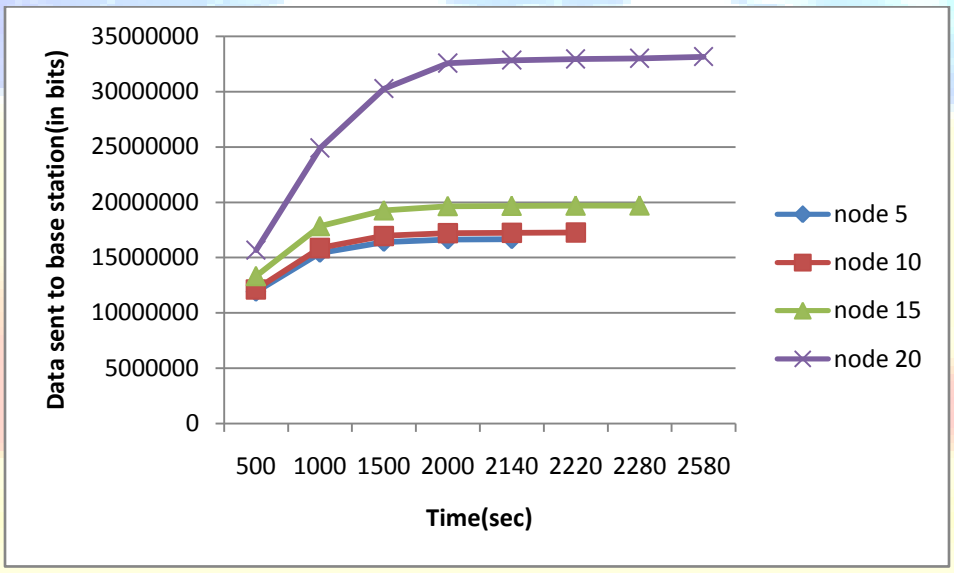


Figure 3: Data sent to base station (bits) vs. time (sec)



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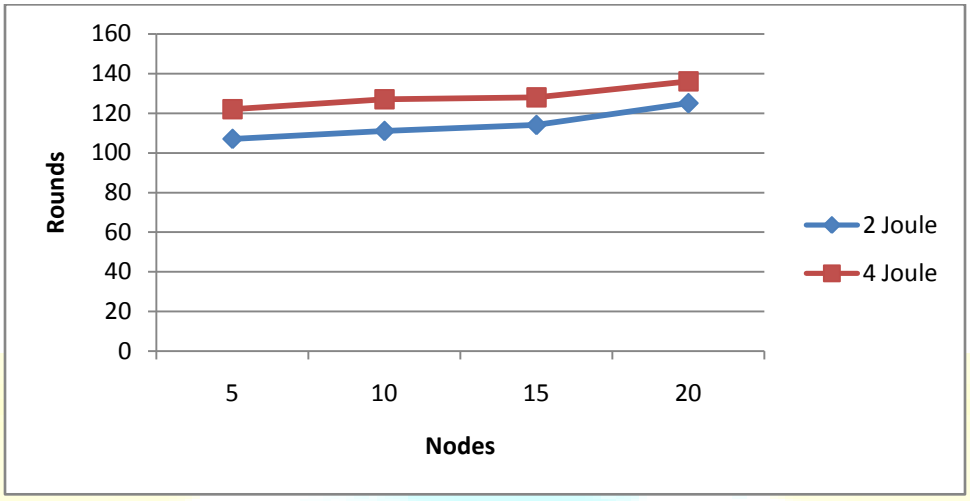

Figure 5: Nodes vs. Rounds

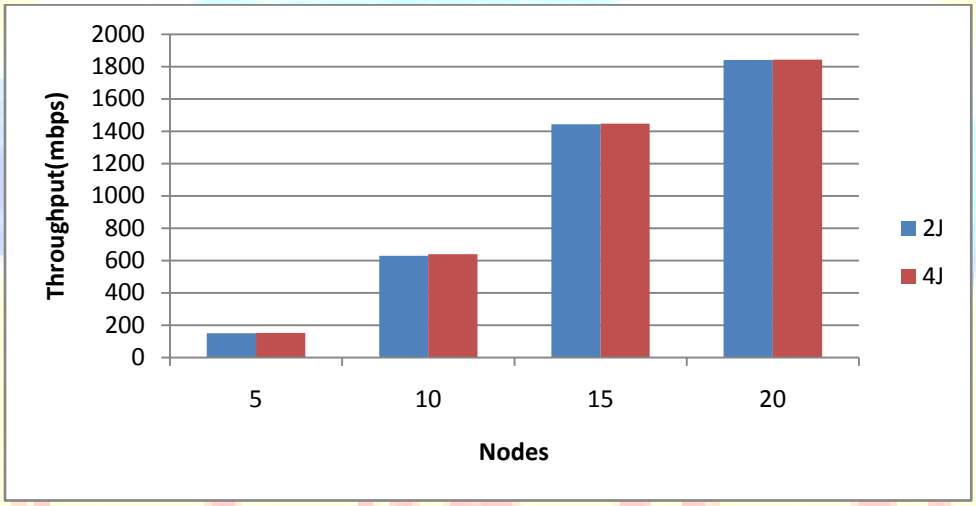

Figure 5: Nodes vs. Throughput (Mbps)

Conclusion

From the simulation results we conclude that on increasing the number of nodes, the lifetime of the network in terms of rounds, the throughput of the network and the data sent to the base station increases. Increase in the initial energy of the nodes from 2 Joule to 4 Joule results in increase of lifetime of the network in terms of rounds and data sent to the base station also increases with this increase in initial energy. On the other hand there is less increase in the value of network throughput.

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