Analysis of Power in WSN Using Energy Harvesting Sources

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Abstract.

There are various studies on Energy Harvesting Wireless Sensor networks in which solar powered nodes are used for communication. In this paper we are looking forward to analyse power in various scenarios by regulating the solar powered nodes in different positions and different protocols. Also, the concept of wireless power transfer is discussed and simulated at length with the help of a simulation tool, Network Simulator 2(NS2)

Keywords. Wireless Sensor Network, LEACH, Internal Power Transfer, NS2.

1. INTRODUCTION

This paper focuses mainly on clustering-based protocol i.e., LEACH C. Energy efficiency and lifetime are two major parameters in the field of Wireless Sensor Network. The Low Energy Adaptive Clustering Hierarchy(LEACH) and Low-Energy Adaptive Clustering Hierarchy-centralized(LEACH-C) are conventional algorithms that partition sensor nodes into clusters and send merged data to the base station(BS). Traditional networks have sufficient energy, and their routing techniques do not take into account the peculiarities of wireless sensor networks. Therefore, they are not suitable for WSN. Low-Energy Adaptive Clustering Hierarchy (LEACH) that employs the technique of clustering nodes in WSN has been proposed. Sensor nodes self-organize into clusters in LEACH, and each cluster chooses a ClusterHead(CH). LEACH-C is a protocol based on clusters in which base stations are randomly selected for cluster heads.

Wireless energy transfer, also known as wireless power transfer, is the capacity to transfer electrical energy without the use of plugs or wires from a source storage to a destination storage. Wireless power transfer has resurfaced with widespread acceptance, with commercial uses such as electric toothbrushes and mobile phone wireless charging(Apple iPhone, Samsung, and others). Near field coupling has been used to facilitate wireless power transfer in applications such as RFID and medical implants.

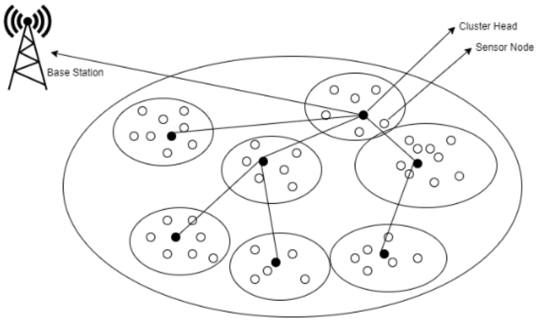

Fig. 1.LEACH C protocol

Inductive coupling, electromagnetic radiation, and magnetic resonant coupling are the three primary categories of wireless power transmission systems.

The restricted energy supply has reduced the longevity of a sensor network, which is powered by wireless sensor nodes. This has been a long-standing and fundamental issue for sensor networks built for long-term operation. To solve the issue, solutions such as energy conservation, environmental energy harvesting, incremental deployment, and battery replacement have been proposed. Energy conservation techniques, on the other hand, can only reduce consumption and not compensate for energy depletion. The availability of environmental energy sources such as solar, wind, and vibration is sometimes unmanageable by humans. Because deserted nodes might damage the environment, the incremental deployment technique may not be eco-friendly.

In this paper we will be proposing a WSN system with Solar Internal Power Transfer (IPT) and compare results by changing the position of Solar Nodes (SNs) in different routing protocols.

2. RELATED WORKS/LITERATURE SURVEY

Energy-Harvesting Wireless Sensor Networks (EH-WSNs): A Review[1] - There are some unique features of energy harvesting wireless sensor nodes. This paper also gives a complete overview on how energy harvesting can be done using various sources of energy. Energy Harvesting in Wireless Sensor Networks: A Survey[2] - Energy harvesting for long-term wireless sensor nodes has been discussed, as well as some of the early solar harvesting pioneers in WSN. Also, it focuses on managing the energy transfer and buffer switching. Based on smart grid applications, a hybrid energy harvesting framework for energy efficiency in wireless sensor networks[3]: This research investigates the effects of reduced sensor node energy consumption while adopting a hybrid energy harvesting technique with a MIP framework that uses transmission power regulation to counteract the harsh environmental conditions of SGs. Maximization of wireless sensor network lifetime using solar energy harvesting for smart agriculture monitoring[4]: This research provides a framework for smart agricultural monitoring applications that has an unlimited life-time SEH-WSN. Design of energy harvesting wireless sensors using magnetic phase transition: This research provides conceptual designs for energy harvesting temperature sensors centred on the magnetic material's Curie temperature. Renewable energy harvesting schemes in wireless sensor networks: A Survey[5]: This study discusses alternative energy management and renewable energy collecting strategies for wireless sensor networks.Comprehensive optimized hybrid energy storage system for long-life solar-powered wireless sensor network nodes[6]: For solar-powered WSN, a new two-port hybrid diode topology is presented. The battery lifetime of a hybrid energy storage system is at least three times that of existing hybrid energy storage systems. Distributed on-demand clustering algorithm for lifetime optimization in wireless sensor networks[7]: This work presents a dynamic cluster head selection-based on-demand clustering algorithm. Reliable and Energy-Efficient Multi-Hop LEACH-Based Clustering Protocol for Wireless Sensor Network[8]: The effectiveness of the low-energy adaptive clustering hierarchy (LEACH) and LEACH-based protocols in extending the lifetime of energy-constrained WSNs is investigated in this study. Enhance multi-hop LEACH, an improved LEACH clustering technique, is proposed to minimise and balance energy consumption in WSNs, allowing for increased packet delivery and network longevity.By using different routing protocols, network lifetime can be extended up somewhat. Regardless, the use of essentialness harvesting techniques lessens the energy utilization use of a particular sensor node by customary aggregate [9]. Many routing strategies are being proposed which uses sun based energy to power up the sensor node like sLEACH, A-sLEACH, IS-LEACH, modified s-LEACH, etc. The issue with the sun aware LEACH[10], advanced sun aware LEACH[11], and IS-LEACH[12] is that they are not in view of real-time sunlight based data. So in modified sun aware LEACH[13], real-time sun oriented data is considered by using a sunlight based charger for voltage and current accounts to ascertain sun based power. While the weather conditions forecast site is there to give us ongoing data about the climate. With respect to, the UV-list information is accessible on the weather conditions forecast. In UV-index based LEACH[14], Author considered these hourly UV-index information for the computation of sun oriented power. To take the advantages of other reaping sources, a wind energy based wLEACH was presented[15]. Wind energy is calculated by considering the real time wind speed data and appropriate wind turbine. Further network lifetime of the network can be extended using the hybrid harvesting sources like solar and wind energy. In[16], Author presented HEH-LEACH where both solar and wind energy is used based on their availability to power up the sensor nodes. With this network lifetime is improved with reduced energy consumption.

3. METHODOLOGY

3.1. Algorithm

The Base station selects CHs from the sensor nodes in the field during the Setup phase (Fig. 2) depending on certain factors (for example, node energy level and the number of times this node has been selected as CH before).A particular CH sends an advertisement message to all other nodes. All nodes that are left out are associated with the CHs closest to them.During the contention period, all nodes in the Steady state phase (Fig. 3) keep their radios active. The cluster-head creates a TDMA schedule and distributes it to all cluster nodes.Within the TDMA time slot already given to them, data is sent from each node to their appropriate CH. The acquired data at each CH is passed forward to the sink during the data transmission to sink phase. Coming to the Internal transfer of Power, the power transfer happens in the steady state phase. The SNs being a part of a cluster continuously transfers power to the cluster head, further the CH makes use of the harvested power in Data collection and Data transmission phase.

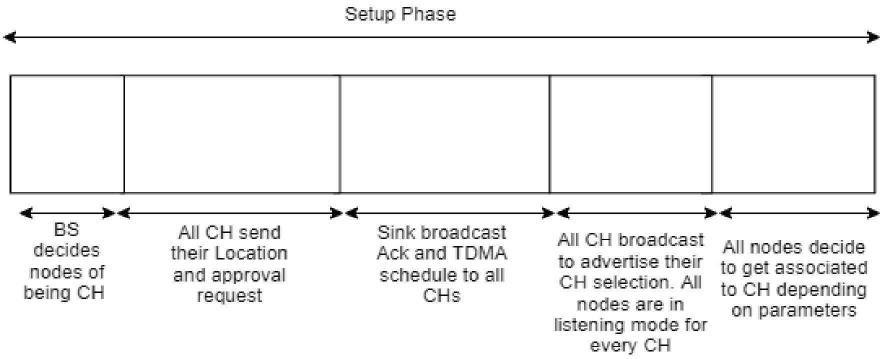

Fig 2. Setup Phase

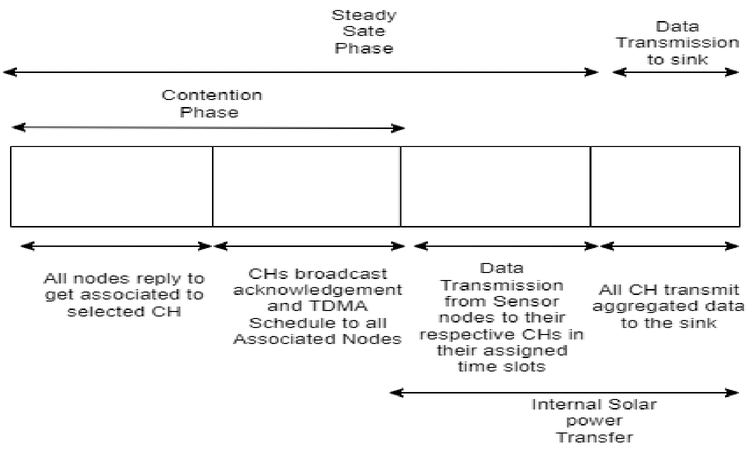

Fig 3. Steady State Phase

3.2. Simulation network scenarios and parameters

Table 1. Steady State Phase

Sr. No	**Parameter**	**Value**
1	Number of solar nodes	5
2	Number of Non solar nodes	47
3	Field size	1500 X 1150
4	Routing Protocol	LEACH and Multihop
5	Packet Size	1024 mb

3.3. Simulation setup

a. Scenario 1: Solar Coordinated node network (LEACH)

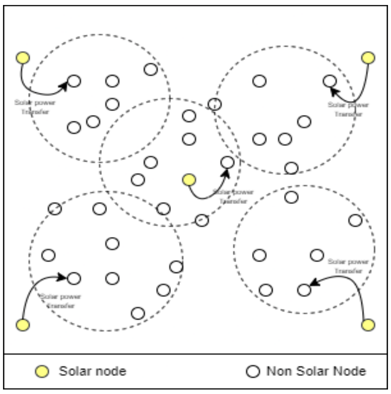

Fig 4. Illustration for Solar Coordinated node network

In this scenario(see fig. 5), namely Coordinated LEACH there are 5 Solar powered nodes from which 4 solar nodes are placed in the corner and 1 solar node is placed in the center. They will be simulated with non-solar powered nodes using LEACH C. Further the solar powered nodes will Internally transfer power to a nearby non solar node preferably a cluster head. As we can observe in the above figure, the yellow circles are solar powered co-ordinated nodes which will transfer the energy to a nearby non-solar node (i.e. white circles) which is highlighted using the pointing arrows. The dotted circles are basically clusters which are formed in the initial phase.

b. Scenario 2: Solar Random node network (LEACH)

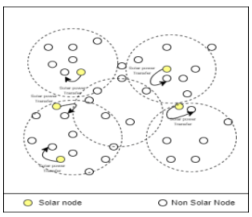

Fig 5. Illustration for Solar Random node network

In this scenario(see fig. 6) there are 5 Solar powered nodes from which all nodes including 5 solar powered nodes are randomly placed. They will be simulated with non-solar powered nodes using LEACH C. Further the solar powered nodes will do internal power transfer to nearby non solar nodes preferably a cluster head. We can observe in the above figure, the yellow circles are solar powered nodes which will transfer the energy to the nearby non-solar nodes (i.e. white circles) where the arrow is pointing. The dotted circles are basically clusters.

c. Scenario 3: Solar Random node network (Multi-hop)

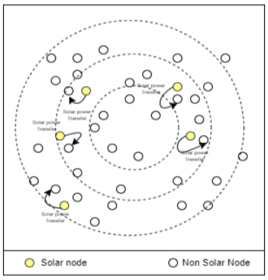

Fig 6. Illustration for Solar Random Multihop node network

In this scenario(see fig. 7) there are 5 Solar powered nodes from which all nodes including 5 solar powered nodes are randomly placed. In multihop the packet travels from source to destination using more than one networking device (i.e. nodes). Further the solar powered nodes will do internal power transfer to nearby non solar nodes. The dotted circles are basically the different hop zone layers.

d. Scenario 4: Non-Solarnode network (LEACH)

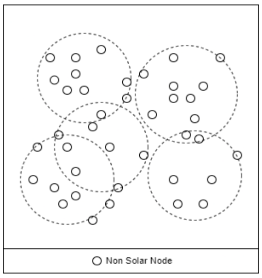

Fig 7. Illustration for Non-Solar LEACH node network

This(see fig. 8) is the basic LEACH C protocol where the cluster heads are formed by the Base Station depending on the basis of the available energy levels of every particular node.

4. RESULTS AND DISCUSSION

4.1 Throughput

Time	LEACH Coordinated	LEACH Random	Multihop	Leach Initial
1	1000	7500	4999	0
50	61200	58700	56200	713
100	112400	76767	107400	4438
150	163600	161100	158600	10663
200	214800	212300	209800	19388
250	266000	187942	261000	30613
300	317200	314700	312200	44338

Table 2. Data packets received w.r.t time in LEACH coordinated with IPT

Time	LEACH Coordinated without IPT	LEACH Random without IPT	Multihop without IPT
1	0	0	0
50	1225	2509	49975
100	4950	5974	64317
150	11175	12199	142425

200	19900	20924	184900
250	31125	32149	149317
300	44850	45874	262350

Table 3. Data packets received w.r.t time in LEACH coordinated without IPT

The Table 2 shows how the LEACH coordinated simulation is working here data packets are linearly Increasing with time while data packets of LEACH coordinated without internal power transfer (IPT) are increasing gradually.

While data packets being received are fluctuating in the LEACH random while data packets of leach random without internal power transfer (IPT) are increasing gradually (Table 3).

Lastly, In the Multihop protocol, data packets are linearly increasing with time while in LEACHInitial, data packets are exponentially increasing with time but as we can see in Table 3, the magnitude of packets being received is very low due to the fact that Solar IPT is not being used here.

4.2 Energy Consumption

Time	**LEACH Coordinated**	**LEACH Random**	**Multihop**	**Leach Initial**
1	1024	0	0	0
50	2453	440	2777	99
100	7635	2454	10489	231
150	15777	5998	27993	359
200	29985	11954	54543	491
250	48625	19680	91637	653
300	75107	29668	137653	803

Table 4. Energy Consumption (J) in Sensor network with IPT

Time	**LEACH Coordinated without IPT**	**LEACH Random without IPT**	**Multihop without IPT**
1	0	0	0
50	1074	49	2176
100	1128	99	9216
150	1196	149	18322
200	1298	199	46626
250	1340	249	73986
300	1420	299	109602

Table 5. Energy Consumption (J) in Sensor network without IPT

The Table 4 shows how the LEACH coordinated simulation is working here. Energy consumption is exponentially Increasing with time while energy consumption of LEACH coordinated without internal power transfer (IPT) is not consumingas much power comparatively due to absence of solar power(Table 5). While, we can observe how the simulation of LEACH random is performing in energy consumption aspect. Energy consumption is exponentially Increasing with time while energy consumption of LEACH random without Solar IPT is changing insignificantly.

Energy consumption of Multihop as well as Multi hop without IPTare exponentially increasing but energy consumption of multihop without communication is slightly less than normal multihop.

As Expected, Energy consumption in LEACH Initialis linearly increasing with time but at a very low magnitude comparatively.

4.3 Efficiency

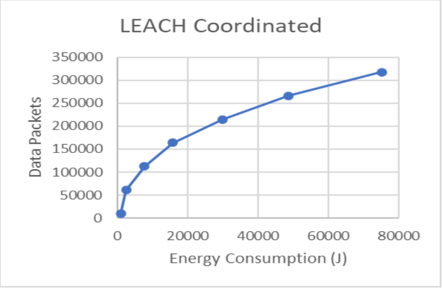

Fig 8. Efficiency of LEACH coordinated

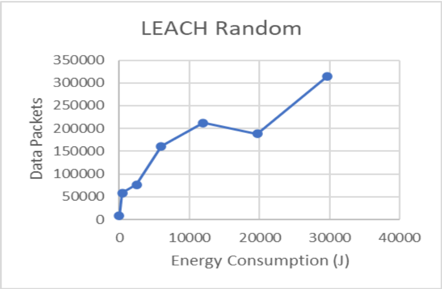

Fig 9. Efficiency of LEACHRandom

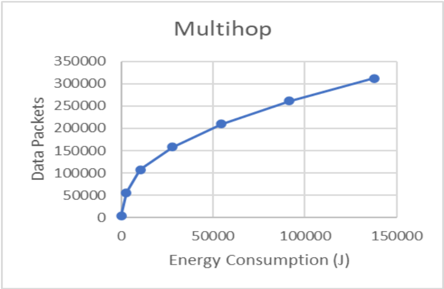

Fig 10. Efficiency of Multihop

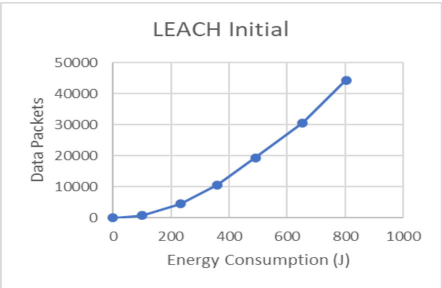

Fig 11. Efficiency of LEACH initial

From the previous Simulation results we were able to conclude the efficiency of the proposed WSN networks. In LEACH coordinated (Fig. 8), The drop in efficiency is stable while in LEACH random the drop is very sharp and fluctuating. On the other side, Multihop solar network (Fig. 10) seems to be very inefficient with high energy consumption. Lastly in LEACH Initial, the efficiency of the system is very stable and growing but is not able to match the magnitude of the proposed network system.

5. CONCLUSION

This research's success will provide a model for effective energy redistribution between nodes, ensuring that nodes do not die, rendering the network unreliable, and therefore resulting in a dependable Wireless Sensor Network (WSN). The proposed models were simulated using the NS-2 simulator through which we compared the effectiveness of the proposed solution in respect to factors like Energy consumption and data throughput. We conclude that Solar Coordinated WSN network is better for data transmission throughout the day while Solar Random WSN network will work efficiently with long sleep cycles or in a system where data transmission is needed after regular intervals.
Simulations are also carried out to evaluate the performance of the proposed system without the use of Solar Internal Power Transfer (IPT) in order to compare the results. The results show that the suggested approach can greatly extend the sensor network's lifetime.

6. FUTURE SCOPE

In our project we simulated the proposed protocol with 5 solar nodes over a small wireless network using solar energy which was transferred wirelessly internally. The proposed simulation being very small in magnitude gave positive results as to how the efficiency as well as the lifetime of a network can be improved. In future this technology can be modified and used in developing smart cities for faster data transmission using clean and renewable energy. Hardware implementation of this project remains to be a challenge right now due to very few options regarding wireless energy transfer but we believe in near future it can be achieved and implemented successfully. Lastly, more such simulations need to be conducted in order to understand proper positioning of solar nodes as per case by case situations.

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