SIMULATION AND ANALYSIS OF IMPROVING LOW-ENERGY ADAPTIVE CLUSTERING HIERARCHY (LEACH)

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Abstract
The sensors (nodes) in sensor networks have limited energy and thus energy-preserving techniques are important. Throughout this study, there are three routing protocol being tested to get the best routing protocol in improving energy consumption. The routing protocol uses are Direct Communication (DC), Minimum Transmission Energy (MTE) and Low Energy Adaptive Clustering Hierarchy (LEACH). DC is more towards direct communication while MTE is multi hop communication whereas LEACH constructs cluster base on radio range and the number of cluster members. LEACH technique improves energy efficiency of the sensor network by selecting a cluster head, and having it aggregate data from other nodes in its cluster and transmit it to the base station. LEACH uses randomized rotation of the cluster-heads to evenly distribute the energy load among the sensor nodes in a network. From simulation, it shows that LEACH is the most energy efficient routing protocol compared to DC and MTE.

I. INTRODUCTION

Since the sensor nodes have limited available power, energy conservation is a critical issue in wireless sensor network for nodes and network life. Therefore, this project paper focused on minimizing the energy consumption. A sensor node is equipped with a limited energy (battery), hence its lifetime is critical. The main objective of a sensor node in a wireless sensor networks (WSN) is to detect any events, processing data, receive and transmit information. Therefore, it is important to keep the minimum energy consumed by each node. Human capability or a mobilizer maybe used to enable the nodes to move around the cluster. This can minimize energy consumption for every node when its can transmits information in a shorter distance. Therefore energy consumption can be divided to three areas; communication, processing and sensing.

Currently, there is a great deal of research in the low-energy radios. [1] Different assumptions about the radio characteristics, including energy dissipation in transmit and receive modes, will change the advantages of different routing protocols. In the research, simple model applied where the radio dissipates Eelec = 50 nJ/bit to run the transmitter or receiver circuitry and Eamp = 100 pJ/bit/m2 for the transmit amplifier to achieve an acceptable Eb/No (see Figure 1and Table 1). These parameters are slightly better than the current state-of-the-art in radio design. In addition, distance in variable r^2 has been used as an energy loss factor due to channel transmission. Therefore, to transmit a k-bit message at a certain distance can be expressed in equation below:

$$E_{Tx}(k; d) = E_{Tx\text{-}elec}(k) + E_{Tx\text{-}amp}(k; d)$$
$$E_{Tx}(k; d) = E_{elec} * k + E_{amp} * k * d^2$$

and to receive this message, the radio expends:

$$E_{Rx}(k) = E_{Rx\text{-}elec}(k)$$
$$E_{Rx}(k) = E_{elec} * k$$

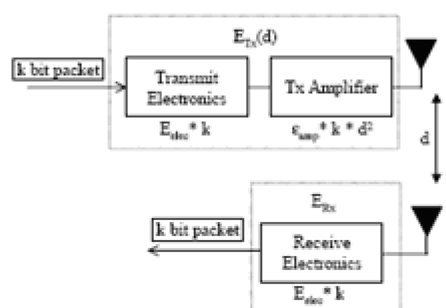

Figure 1: First Order Radio Model

Operation	Energy Dissipated
Transmitter Electronics ($E_{Tx-elec}$) Receiver Electronics ($E_{Rx-elec}$) ($E_{Tx-elec} = E_{Rx-elec} = E_{elec}$)	50 nJ/bit
Transmit Amplifier (ϵ_{amp})	100 pJ/bit/m^2

Table 1:Radio Characteristics

For these parameter values, receiving a message is not a low cost operation; the routing protocols should thus try to minimize not only the transmit distances but also the number of transmit and receive operations for each message. Assumed that, radio channel is symmetric such that the energy required to transmit a message from node A to node B is the same as the energy required to transmit a message from node B to node A for a given signal to noise ratio (SNR). In the experiment, all sensors are sensing the environment at a fixed rate and thus always have data to send to the end-user.

II. METHODOLOGY

There have been several networks routing protocol for wireless networks, which are direct communication (DC), minimum transmission energy (MTE) and low energy adaptive clustering hierarchy (LEACH).

For direct communication routing protocol, data was sent directly to the base station. Figure 2 shows the base station is far away from the nodes, the direct communication will require a large amount of transmit power or energy from each node. Since the distance is concerned, it does require more energy or power for the node that far away from base station to transmit the data. This will rapidly drain the battery of the nodes while reducing the system lifetime. Therefore, for DC either the base station is close to the nodes or the energy is large, this routing protocol can be executed for communication.

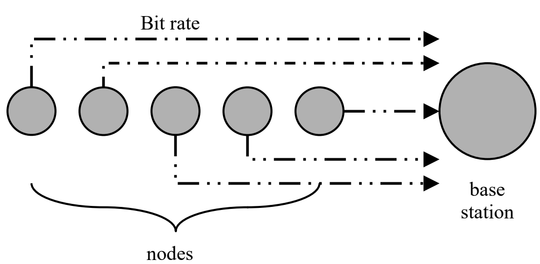

Figure 2: Direct Communication (DC)

Second method is minimum transmission energy (MTE). In figure 3, the nodes closest to the base station will rapidly drain their energy resources since these nodes engage in the routing of a large number of data transmitted to the base station. In other words, it is multi hop communication concept.

Bit rate

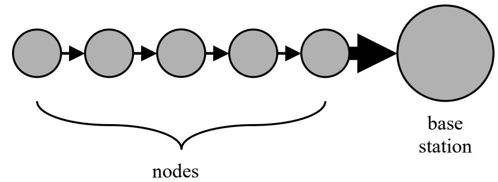

Figure 3: Minimum Transmission Energy (MTE)

Finally, the best method is by using Low Energy Adaptive Clustering Hierarchy (LEACH). It improves energy efficiency of the sensor network by selecting a cluster head, and having it aggregate data from other nodes in its cluster and transmit it to the base station. Figure 4 shows clustering concept was used in LEACH routing protocol.

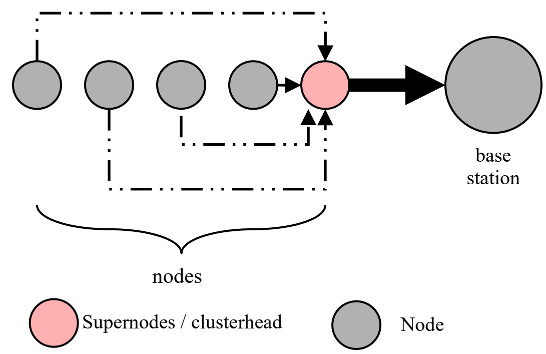

Figure 4: Low Energy Adaptive Clustering Hierarchy (LEACH)

DC	MTE	LEACH
i. Simplest topologies	Flat topologies	Hierarchical routing protocol
ii. Sensor nodes routes data through intermediary nodes.	Sensor nodes are one hop away from base station.	Sensor nodes are organized into cluster.
iii. Required more energy but less that MTE routing protocol.	Required large amount of transmit power, thus required more energy.	Required less energy because the high-energy dissipation in communicating with the base station is spread to all sensor nodes in the sensor network.

Table 2 shows the differences of (i) architecture, (ii) routing protocol and (iii) transmit power between DC, MTE and LEACH Routing Protocol.

Parameters

E_{Rx} = transmit energy
E_{elec} = electronic radio energy
E_{amp} = amplifier energy
k = transmit energy

r = distance
n = node

$E_{Rx}(k) = E_{elec} * k$

Edirect(r) = k*(Eelect + (Eamp)*(n^2)*(r^2))

Emte(r) = k*(((2*n)-1)* Eelect) + (Eamp * (n) * (r^2))

Eleach(r) = k*(Eelect + ((Eamp)*(r^2)) + Erx)

III. RESULTS ANALYSIS

1. The graphs in figure 5 were obtained using 2000 bits. Distance was varies from 1m to 100m with 100 nodes. The data were tabulated in Table 3.

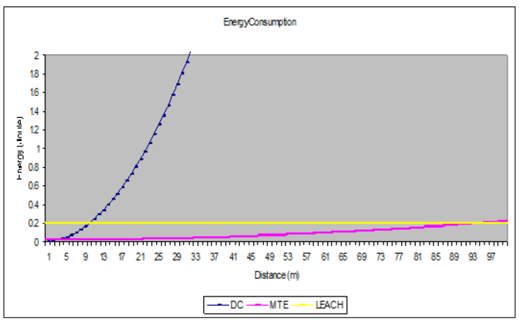

Figure 5: Energy vs. distance for DC, MTE and LEACH at distance 1m to 100m.

Distance (m)	Energy consumption for DC protocol	Energy consumption for MTE protocol	Energy consumption for LEACH protocol
1	0.0021	0.01992	0.20010
10	0.2001	0.0219	0.20012
20	0.8001	0.0279	0.20018
30	1.8001	0.0379	0.20028
40	3.2001	0.0519	0.20042
50	5.0001	0.0699	0.2006
60	7.2001	0.0919	0.20082
70	9.8001	0.1179	0.20108
80	12.8	0.1479	0.20138
90	16.2	0.1819	0.20172
100	20	0.2199	0.20210

Table 3: Results of energy consumption at distance from 1m to 100m.

It shows that DC consumed much higher energy compared to other two routing protocols. The energy consumed in LEACH is slightly increased for the distance from 1m to 100m.

Upon exceed 100m, LEACH become more efficient compared to MTE and DC.

Further simulation had been made for distance up to 200m. This is to show the pattern of the graph when the distance is more than 100m

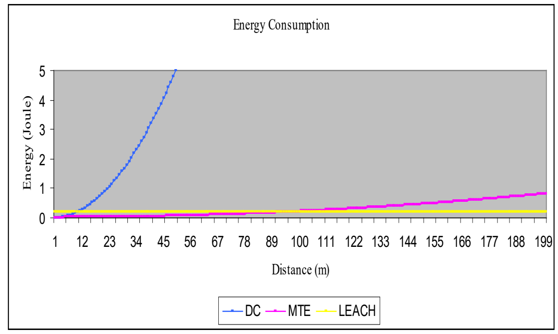

Figure 6: Energy vs. distance for DC, MTE and LEACH at distance 1m to 200m.

Distance (m)	Energy consumption for DC protocol	Energy consumption for MTE protocol	Energy consumption for LEACH protocol
1	0.0021	0.01992	0.2001
20	0.8001	0.0279	0.20018
40	3.2001	0.0519	0.20042
60	7.2001	0.0919	0.20082
80	12.8	0.1479	0.20138
100	20	0.2199	0.2021
120	28.8	0.3079	0.20298
140	39.2	0.4119	0.20402
160	51.2	0.5319	0.20522
180	64.8	0.6679	0.20658
200	80	0.8199	0.2081

Table 4: Results of energy consumption at distance from 1m to 200m.

From graph in figure 6, upon exceed 100m, LEACH still become more efficient compared to MTE and DC. It was proved by looking at the graph where energy consumption for MTE was increasing higher than LEACH. The data was tabulated at Table 4.
These also prove the theory of routing protocol energy dissipation which closer distance can minimize the energy consumption.

2. By applying the same bit rate, distance at 100m and node ranging from 1 to 100 nodes, the graph in figure 7 was obtained. The analysis of data was shown in Table 5.

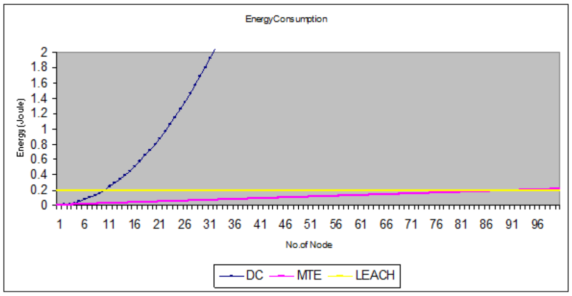

Figure 7: Energy vs. No. of node for DC, MTE and LEACH at distance 100m.

Number Of Nodes	Energy consumption for DC protocol	Energy consumption for MTE protocol	Energy consumption for LEACH protocol
1	0.0021	0.0021	0.2021
10	0.2001	0.0219	0.2021
20	0.8001	0.0439	0.2021
30	1.8001	0.0659	0.2021
40	3.2001	0.0879	0.0201
50	5.0001	0.1099	0.2021
60	7.2001	0.1319	0.2021
70	9.8001	0.1539	0.2021
80	12.8	0.1759	0.2021
90	16.2	0.1979	0.2021
100	20	0.2199	0.2021

Table 5: Result of energy consumption with 1 to 100 nodes at distance 100m

From the graph in figure 6, DC routing protocol consumed the most energy among the routing protocol. Meanwhile by comparison energy consumption between MTE and LEACH, the simulation result shown constant energy utilization for LEACH protocol while MTE shown increase of energy usage proportionate with number on node. It is clear that LEACH routing protocol does not require so much energy to operate when number of node increase.

IV. CONCLUSION

Analysis and simulation were presented for three routing protocol which are DC, MTE and LEACH, to see the differences in energy efficiency. From the simulation results, all three routing protocols really do consume some amount of energy during transmission. However MTE routing protocol had shown exponential energy consumed during increasing of transmission distance. Whereas DC routing protocol shown the most highly energy consumed when distance increased. Therefore among three routing protocol analysis under distance factor, LEACH routing protocol could be considered as the best routing protocol for energy saving.

Node analysis also had shown similar result with distance analysis where among those three routing protocols, LEACH routing protocol could be considered the best energy consumption routing protocol. The analysis shown constant energy consumption for LEACH whereas other two routing protocol shown increasing trend in energy usage when number of nodes increasing.

It can be concluded that, LEACH routing protocol is an energy efficient routing protocol compared to DC and MTE. Energy in LEACH emitted in small amount of joule when distance of node with base station increasing accordingly. Another advantage of LEACH compare to other routing protocol is about number of node creation. Other routing protocol had shown increasing of energy consumption when number of node increased but LEACH shown constant value due to cluster architecture design.

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