Performance Analysis of Energy Efficient Protocols for Wireless Sensor Networks

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Abstract— Data collection is a major function of many applications in wireless sensor networks (WSNs). Practically it is not possible to say that all sensors have the same energy because they have different energy consumptions. In this paper, we have provided the clustering which can be done in two types of networks, homogeneous and heterogeneous networks on the basis of energy consumptions. Homogeneous are those in which nodes have same initial energy while heterogeneous networks are those in which nodes have different initial energy. In this paper, we have studied heterogeneous networks in three levels (Two-Level Heterogeneity, Three-Level Heterogeneity and Three Class Heterogeneity).
Distributed Energy Efficient Clustering (DEEC) algorithm is Clustering based algorithm in which cluster head is selected on the basis of probability of ratio of residual energy and the average energy of the network. So, in this algorithm, a node which has more energy has more chances to be a cluster head. ClassicDEEC-3 class and DEEC-3 level perform better than the DEEC-2 level heterogeneity. We have extended it to three-classes of heterogeneity by introducing class 2 nodes and called this extension of the ClassicDEEC-3 class.

Keywords— WSN, DEEC, LEACH, cluster-based protocol.

I. INTRODUCTION

WSN is a combination of wireless communication and sensors Devices. These devices have some sort of sensing the physical environment. Sensing tasks for these devices may include temperature, humidity, light, sound, vibration, etc. These devices are known as sensor nodes or motes. Many protocols and algorithms are used to gather information from these networks [1].WSNs is the network consisting of more than hundred compact and tiny sensor nodes, which senses the physical environment in terms of temperature, humidity, light, sound, vibration, etc. These sensor nodes gather the data from the sensing field and send this information to the end user. These sensor nodes can be deployed in many applications. Current WSN is working on the problems of low-power communication, sensing, energy storage, and computation. Currently wire- less system are dealing with surface of possibilities emerging from the integration of low-power Communication, sensing, energy storage, and computation.

II. RELATED WORK

The nodes available in sensor network are generally converting themselves into clusters, whose energy level is highest among their counterpart. Clustering allows hierarchical structures to be built with the nodes and enables more networks, called Low Energy Adaptive Clustering efficient use of scarce resources, such as frequency spectrum, bandwidth and power [2]. Heinzelman [3] introduced a hierarchical clustering algorithm for sensor networks, called Low Energy Adaptive Clustering (LEACH).LEACH is a cluster-based protocol, which includes distributed cluster formation [4]. The LEACH is composed of two phases: a setup phase and a steady-state phase. The setup phase creates the clusters inside the network and elects the cluster heads in each cluster. In the steady-state phase the nodes inside each cluster sense the data and transmit it to the cluster head. The Adaptive Threshold sensitive Energy Efficient sensor Network protocol (APTEEN) [5] is an extension to TEEN and aims at both capturing periodic data collections and reacting to time-critical events. The architecture is same as in TEEN. When the base station forms the clusters, the cluster heads broadcast the attributes, the threshold values, and the transmission schedule to all the nodes. Cluster heads also perform data aggregation in order to save energy. APTEEN supports three different query types: historical, to analyze past data values; one-time, to take a snapshot view of the network; and persistent to monitor an event for a period of time. The experiments have demonstrated that APTEEN's performance is between LEACH and TEEN in terms of energy dissipation and network lifetime. TEEN gives the best performance as it decreases the number of transmissions.

III. SYSTEM MODEL

A. Sensor network model: Assume that N sensor nodes are randomly and uniformly Distributed over which sensing field and sensor network has following parameters:

1. Sensor Node: A sensor node is the core component of a WSN. Sensor nodes can take on multiple roles in a network, such as simple sensing; data storage; routing; and data processing.
2. Clusters: Clusters are the organizational unit for WSNs. The dense nature of these networks requires the need for them to be broken down into clusters to simplify tasks such a communication.
3. Cluster heads: Cluster heads are the organizational leader of a cluster. They often are required to organize activities in the cluster. These tasks include, but are not limited to data- aggregation and organizing the communication schedule of a cluster.
4. Base Station: The base station is at the upper level of the Hierarchical WSN. It provides the communication link between the sensor network and the end-user.
5. End User: The data in a sensor network can be used for a Wide-range of applications [5]. So, a particular application may make use of the network data over the internet, using a PDA, or even a desktop computer. In a queried sensor network (where the required data is gathered from a query sent through the network).
6. Data Packets received at base station: It is the total number of data packets or messages that are received by the base station.
7. Number of alive nodes: This instantaneous measure reflects the total number of nodes and that of each type that has not yet expended all of their energy [6].
8. Number of dead nodes: This instantaneous measure reflects the total number of nodes and that of each type that have expended all of their energy [6].
9. Network remaining energy: It measures the total remaining energy of the network. It is calculated at each transmission round of the protocol.

of the advanced nodes, which provides a time at which it has more energy than the normal ones. Thus, there are m.N advanced nodes equipped with an initial energy of Eo(1 + a) and (1- m). Energy of the two-level heterogeneous networks is given by [9].

$$E_{total} = N.(1-m).E0 + m.N.(1+a).E0$$

$$E_{total} = N.E0(1+a.m)$$

Therefore, the two-level heterogeneous networks have a.m times more energy and virtually a. m more nodes [9].

Three-level heterogeneous networks In three-level heterogeneous networks, there are three types of Sensor nodes [10, 11]. They are normal nodes, advanced nodes and super nodes. Let m be the fraction of the total number of nodes N, and mo is the percentage of the total number of nodes which are equipped with b times more energy than the normal nodes, known as super nodes, the number is N.m.mo. The rest N.m.(1-mo) nodes are equipped with a times more energy than the normal nodes; known as advanced nodes and remaining N.(1-m) as normal nodes. The total initial energy of the three-level heterogeneous networks are given by [10,11]

$$E_{total} = N.(1-m).E0 + m.N.(1-mo).(1+a).E0 + N.m.mo.E0.(1+b)$$

$$E_{total} = N.E0(1+m(a+mo.b))$$

B. Types of heterogeneous resources

There are three common types of resource heterogeneity in sensor node: computational heterogeneity, link heterogeneity, and energy heterogeneity [7-8].

Computational heterogeneity means that the heterogeneous node has a more powerful microprocessor and more memory than the normal node. With the powerful computational resources, the heterogeneous nodes can provide complex data processing and longer-term storage.

Link heterogeneity means that the heterogeneous node has high-bandwidth and long-distance network transceiver than the normal node. Link heterogeneity can provide more reliable data transmission.

Energy heterogeneity means that the heterogeneous node is line powered, or its battery is replaceable. Among above three types of resource heterogeneity, the most important heterogeneity is the energy heterogeneity because both computational heterogeneity and link heterogeneity will consume more energy resource.

C. Heterogeneous Networks Used We have used heterogeneous network under three conditions described as following section

- Two-level heterogeneous networks
- Three-level heterogeneous networks
- Three-Class heterogeneous networks

Two-level heterogeneous networks In two-level heterogeneous networks, there are two types of sensor nodes [9].Which are normal nodes and advanced nodes. Eo is the initial energy of the normal nodes, and m is the fraction Therefore, the three-level heterogeneous networks have m. (a + mo. b) times more energy or we can say that the total energy of the system is increased by a factor of (1+ m. (a + mo. b)) [10, 11].

Radio Energy Dissipation Model

Radio Energy Model used is based on [13]. Energy model for the radio hardware energy dissipation where the transmitter dissipates energy to run the radio electronics and the power amplifier, and the receiver dissipates energy to run the radio electronics is shown in Figure 1.1 [13]

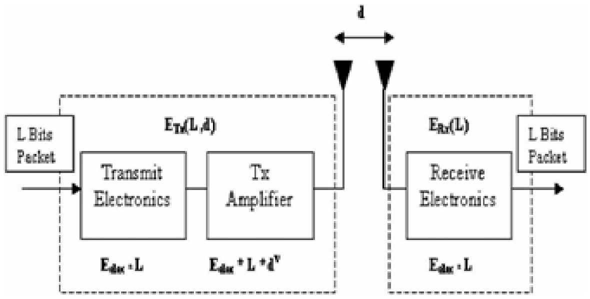

Fig 1.1: Radio Energy Dissipation Model

Here both the free space (d2 power loss) and the multipath fading (d4 power loss) channel models were used, depending on the distance between the transmitter and receiver [7, 8]. Power control can be used to invert this loss by appropriately setting the power amplifier—if the distance is less than thresholds do, the free space model is used; otherwise, the multipath model is used

IV. SIMULATION RESULTS

A. Simulation Parameters

In simulation, we have evaluate the performance of DEEC-2, DEEC - 3, and ClassicDEEC - 3 in the same heterogeneous setting, and for network lifetime, number of alive nodes per round, and network overhead lifetime.

The parameters of the simulations are listed in Table I

Table I. Simulation Parameters

Parameters	Value
Network Field	-100,100
Number of nodes	100
Eo (Initial energy of normal nodes)	0.5 J
Message Size	4000 Bits
Eelec	50nJ/bit
Efs	10nJ/bit/m2
Eamp	0.0013pJ/bit/m4
EDA	5nJ/bit/signal
do(Threshold Distance)	70m
333popt	0.1

V. IMPLEMENTATION SETUP

The Implementation is based on the methodology discussed in Section 2.3 about network model, energy model and implementation of two-level, three-level and three-class heterogeneity we have taken following cases.

For two-level heterogeneity

Case 1: m=0.2, a=2

Case 2: m=0.2, a=1.5

For three-level heterogeneity

Case 1: m=0.2, mo=0.5, a=1.5, b=2 Case 2: m=0.5, mo=0.4, a=1.5, b=3

For three-class heterogeneity

Case 1:Ɵ1=0.3, Ɵ2=0.2, a=2

Case 2: Ɵ1=0.5, Ɵ2=0.4, a=3

Simulation results

Case 1 (m=0.2, a=2), (m=0.2, mo=0.5, a=1.5, b=2) and (Ɵ1=0.3, Ɵ2=0.2, a=2):

Figure 4.1 and Figure 4.2 represent the number of nodes that are alive and dead during the lifetime of the network. These results clearly show that stability period of Classic DEEC-3 Class is longer as compared to DEEC-3 Level and DEEC-2 Level and unstable period of DEEC-2 Level is longer than DEEC-3 Level and DEEC-3 Level is longer than ClassicDEEC-3 Class. According to lifetime metric we have used the lifetime of DEEC-3 Level is more as compared to DEEC-2 Level. In DEEC-2 Level death of nodes starts after 1500 rounds while for DEEC-3 Level it starts after 1700 and ClassicDEEC-3 Class starts after 1750 rounds. Last node of DEEC-2 Level, DEEC-3 Level and ClassicDEEC-3 Class dies at the 2500, 2700 and 3500 rounds, respectively.

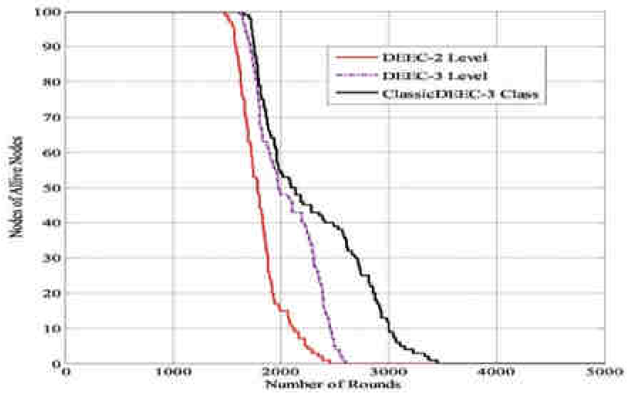

Fig 4.1: Number of nodes alive over no. of rounds under two-level and three heterogeneity of DEEC-2 Level, DEEC-3 Level and ClassicDEEC-3 Class

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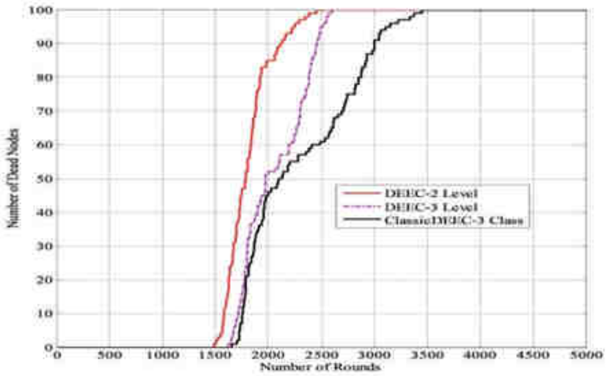

Fig.4.2: Number of nodes dead over no. of rounds under two-level and three heterogeneity of DEEC-2 Level, DEEC-3 Level and ClassicDEEC-3 Class

Figure 4.3 shows the comparison in terms of number of data packets received at the base station. The results show that for all the protocols it goes linearly for around 1000 rounds and after that the difference can be seen. It is clear ClassicDEEC-3 Class has more numbers of data packets received at base station in comparison to DEEC-3 Level and DEEC-2 Level. The number of packet transfer to base station of DEEC-2 Level, DEEC-3 Level and Classic DEEC-3 Class as 2.6 x 104, 3.4 x 104 and 3.8 x 104 with respect to number of rounds, respectively. Data packets received at base station per round is more in case of DEEC 3 classes as compared to 2 level and 3 level.

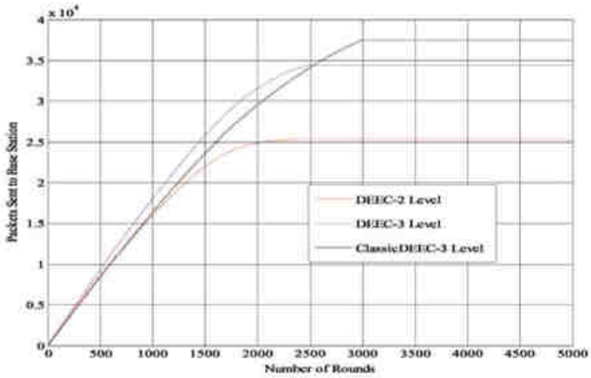

Fig 4.3: Data Packets over no. of rounds under two-level and three heterogeneity of DEEC-2 Level, DEEC-3 Level and ClassicDEEC-3 Class

Figure 4.4 show total remaining energy over time i.e., number of rounds. Here total initial energies are 70 J, 80J and 90J which decreases up to around 2200, 2500 and 3300 rounds for DEEC- 2 Level, DEEC-3 Level and ClassicDEEC-3 Class, respectively. Energy per round is more in ClassicDEEC-3 Class as compared to DEEC-2 Level and DEEC-3 Level

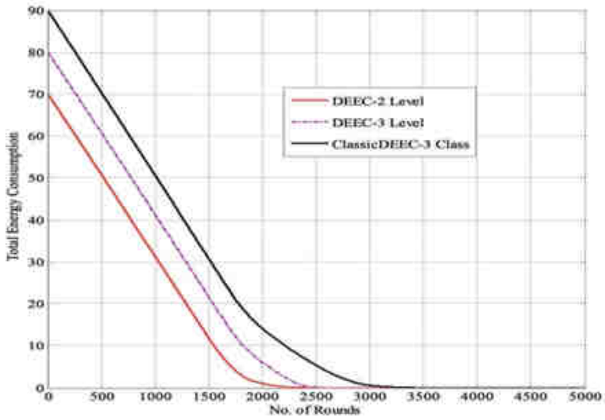

Fig 4.4: Total remaining energy over rounds two level and three heterogeneity of DEEC-2 Level, DEEC-3 Level and ClassicDEEC-3 Class

Case II (m=0.2, a=1.5), (m=0.5, mo=0.4, a=1.5, b=3) and (ϴ1=0.5, ϴ2=0.4, a=3):

Figure 4.5 and Figure 4.6 represent the number of nodes that are alive and dead during the lifetime of the network. These results clearly show that stability period of Classic DEEC-3 Class is longer as compared to DEEC-3 Level and DEEC-2 Level and unstable period of DEEC-2 Level is longer than DEEC-3 Level and DEEC-3 Level is longer than ClassicDEEC-3 Class. According to lifetime metric we have used the lifetime of DEEC-3 Level is more as compared to DEEC-2 Level. In DEEC-2 Level death of nodes starts after 1500 rounds while for DEEC-3 Level it starts after 1700 and ClassicDEEC-3 Class starts after 1900 rounds. The last node death of DEEC-2 Level, DEEC-3 Level and Classic DEEC-3 Class as 2200, 4000 and 6000 number of rounds, respectively

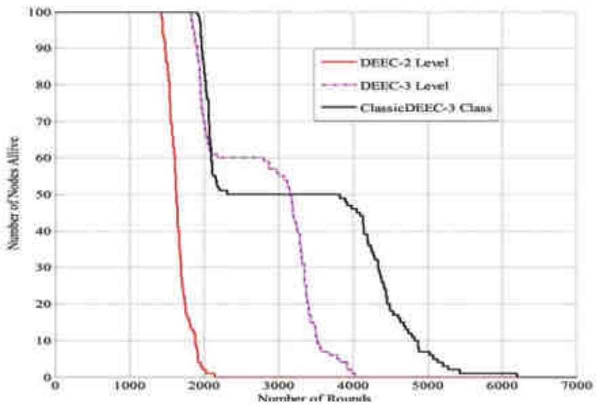

Fig 4.5: Number of nodes alive over no. of rounds under two-level and three heterogeneity of DEEC-2 Level, DEEC-3 Level and ClassicDEEC-3 Class

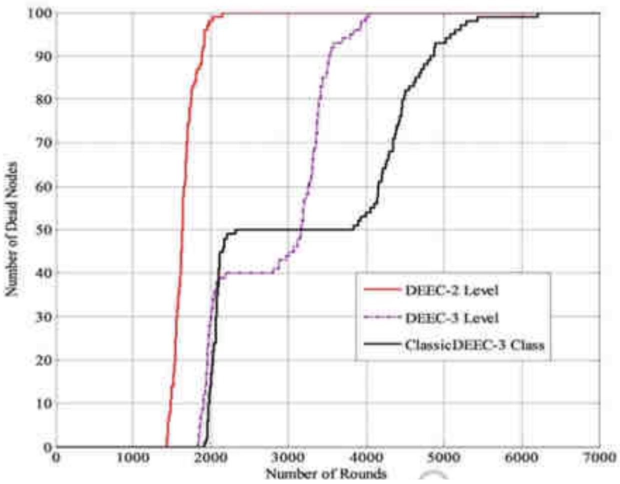

Fig 4.6: Number of nodes dead over no. of rounds under two-level and three heterogeneity of DEEC-2 Level, DEEC-3 Level and ClassicDEEC-3 Class

Figure 4.7 shows the comparison in terms of number of data packets received at the base station. The results show that for all the protocols it goes linearly for around 1000 rounds and after that the difference can be seen. It is clear ClassicDEEC-3 Class has more numbers of data packets received at base station in comparison to DEEC-3 Level and DEEC-2 Level. The number of packet transfer to base station of DEEC-2 Level, DEEC-3 Level and Classic DEEC-3 Class as 1.9 x 104, 3.3 x 104 and 7.0 x 104 with respect to number of rounds, respectively. It is clear DEEC has more numbers of data of data packets received at base station in comparison to three classes

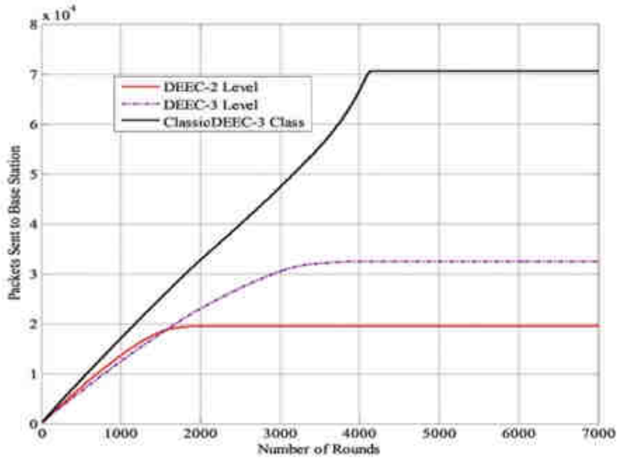

Fig 4.7: Data Packets over no. of rounds under two-level and three heterogeneity of DEEC-2 Level, DEEC-3 Level and ClassicDEEC-3 Class

Figure 4.8 show total remaining energy over time, i.e. number of rounds. Here total initial energies are 64 J, 105J and 122J which decreases up to around 2200, 4000 and 5500 rounds for DEEC-2 Level, DEEC-3 Level and ClassicDEEC-3 Class,

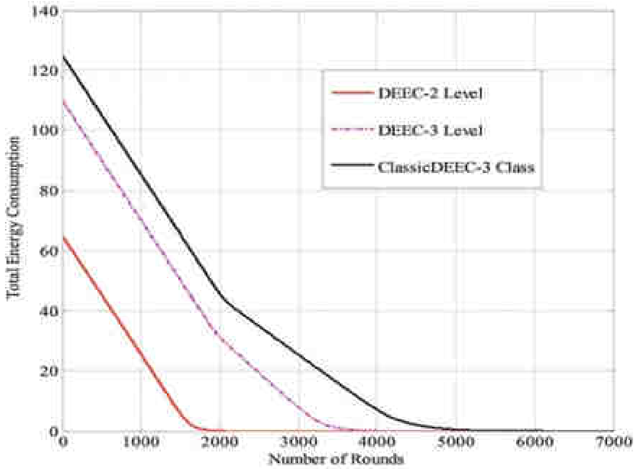

Fig 4.8: Total remaining energy over no. of rounds under two-level and three heterogeneity of DEEC-2 Level, DEEC-3 Level and ClassicDEEC-3 Class

VI. CONCLUSION

We have described the approach used, i.e., base of our work,DEEC protocol [9]. We have discussed the cluster selection algorithm followed in this paper by describing the threshold and probability equation for two-level, three-level, and three class's heterogeneity.

We have performed this approach on DEEC for two-level, three

levels and ClassicDEEC-3 level with three classes of nodes. We have concluded that performance of DEEC-3 level and ClassicDEEC-3 class is much better than DEEC-2 level under energy consumptions. DEEC-3 level and ClassicDEEC-3 class prolong more lifetime as compared to DEEC 2 level. So we can conclude that more the energy level of the network represents more stable network and more is the lifetime

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