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Study of Clustering in Heterogeneous nodes in WSN

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Abstract: The performance of DEEC clustering algorithms on the basis of stability period has been described in this paper. Network life time and throughput for different level of heterogeneous wireless sensor networks has been analysed on the basis of prolonging stability period. Network life time of nodes alive during rounds for numerous three level heterogeneous networks. Information from sensor nodes is forwarded to cluster heads (CHs) and these CHs are responsible to transmit this information to base station (BS) which is placed far away from the field.

Keywords: clustering, cluster heads, protocols application, WSNs.

I. INTRODUCTION

Wireless Sensor Networks (WSNs) are ad-hoc networks, consisting of spatially distributed devices (motes) using sensor nodes to cooperatively monitor physical or environmental conditions at different locations. Devices in a WSN are resource constrained; they have low processing speed, storage capacity, and communication bandwidth. In most settings, the network must operate for long periods of time, but the nodes are battery powered, so the available energy resources limit their overall operation. To minimize energy consumption, most of the device components, including the radio, should be switched off most of the time [1]. Another important characteristic is that sensor nodes have significant processing capability in the ensemble, but not individually. Nodes have to organize themselves, ad-ministering and managing the network all together, and it is much harder than controlling individual devices. Furthermore, Sensor nodes have ability to sense and send sensed data to Base Station (BS). Sensing as well as transmitting data towards BS requires high energy. In WSNs, saving energy and extending network lifetime are great challenges. Clustering is a key technique used to Optimize energy consumption in WSNs.

II. WIRELESS SENSOR NETWORKS (WSNS)

If Wireless Sensor Networks (WSN) have gained world-wide attention in recent years due to the advances made in wireless communication, information technologies and electronics field. The development of low-cost, low-power, a multifunctional sensor has received increasing attention from various industries. Sensor nodes or motes in WSNs are small sized and are capable of sensing, gathering and processing data while communicating with other connected nodes in the network, via radio frequency (RF) channel. Wireless sensor network [3] are one of the category belongs to ad-hoc networks. Sensor network are also composed of nodes [4]. Here actually the node has a specific name that is “Sensor” because these nodes are equipped with smart sensors. A sensor node is a device that converts a sensed characteristic like temperature, vibrations, pressure into a form recognize by the users. Wireless sensor networks nodes are less mobile than adhoc networks. So mobility in case of ad-hoc is more. In wireless sensor network data are requested depending upon certain physical quantity, so wireless sensor network is data centric [7]. A sensor consists of a transducer, an embedded processor, small memory unit and a wireless transceiver and all these devices run on the power supplied by an attached battery.

III. RELATED WORK

Works done by different authors are as follows:

In [1], Stojmenovic et. al describe a cost aware metric for wireless networks based on remaining battery power at nodes was proposed for shortest-cost routing algorithms, assuming constant transmission power. Power-aware metrics, where transmission power depends on distance between nodes and corresponding shortest power algorithms were also proposed. We define a power-cost metric based on the combination of both node's lifetime and distance-based power metrics. The power-aware routing algorithm attempts to minimize the total power needed to route a message between a source and a destination.

In [2], Kulkarni et. al present a scheme that replaces conventional MAC addresses with dynamically assigned short link labels that are spatially reused. This would be useful in self-configuring sensor networks. We also present an encoded representation of these labels for use in data packets. We develop a distributed algorithm involving local exchange of control messages for the assignment of these labels. Simulation results demonstrate the scalability of the assignment algorithm and the encoded label representation. In typical scenarios, the MAC header is reduced by a factor of eight as compared to traditional MAC headers

In [3], Tian et. al. identify the drawbacks of pure single path routing scheme and multipath routing scheme, in terms of guaranteed delivery with low energy consumption. Accordingly, we describe a scheme, in which data is forwarded along a pre-established single path to save energy, and a high delivery ratio is achieved by path repair whenever a break is detected. We propose a simple, quick, local path repairing approach, whereby a pivot node can skip over path break by only using the already existing routing information in its neighborhood. We implement this scheme and compare its performance with those of pure single path without repair and two multipath routing schemes.

In [4], Papadopoulos et. al. developments in wireless, mobile communications combined with advancements in electronics have contributed to the emergence of a new class of networks: wireless ad-hoc sensor networks.

In [5], Akkaya et. al analyzes almost all of the energy-aware routing protocols that have been proposed for wireless sensor networks aim at optimizing network performance while relaying data to a static gateway (sink). However, mobility of the gateway can make routes established through such contemporary protocols, unstable and non-optimal.

In [6], Zhang et. al explore the problem of location-aided multicast routing for WSN. A sensor network of nodes with location information and limited energy is considered. As the problem is NP-hard, we propose four heuristic schemas to construct the geomulticast routing tree, namely, single branch regional flooding, single branch multicast tree, cone-based forwarding area multicast tree and MST-based single branch multicast tree.

IV. CLUSTERING

DEEC is designed to deal with nodes of heterogeneous WSNs. For CH selection, DEEC uses initial and residual energy level of nodes. Let ni denote the number of rounds to be a CH for node is Popt N is the optimum number of CHs in our network during each round[6]. CH selection criteria in DEEC are based on energy level of nodes. As in homogenous network, when nodes have same amount of energy during each epoch then choosing pi = popt assures that poptN CHs during each round. In WSNs, nodes with high energy are more probable to become CH than nodes with low energy but the net value of CHs during each round is equal to poptN. pi is the probability for each node si to become CH, so, node with high energy has larger value of pi as compared to the popt. E(r) denotes average energy of network during round r which can be given as in [2].

$$R = \frac{E_{total}}{E_{round}}$$

In DEEC the average total number of CH during each round is given as

$$\sum_{i=1}^{N} p_i = \sum_{i=1}^{N} p_{opt} \frac{E_i(r)}{\bar{E}(r)} = p_{opt} \sum_{i=1}^{N} \frac{E_i(r)}{\bar{E}(r)} = N p_{opt}$$

pi is probability of each node to become CH in a round. Where, G is the set of node eligible to become CH at round r. If node becomes CH in recent rounds then it belongs to G. During each round each node chooses a random number between 0 and 1. If number is less than threshold as defined below, it is eligible to become a CH else not.

$$T(s_i) = \begin{cases} \frac{p_i}{1 - p_i (r \bmod \frac{1}{p_i})} & if\ s_i \epsilon G \\ 0 & otherwise \end{cases}$$

As popt is reference value of average probability pi.

In homogenous networks, all nodes have same initial energy so they use popt to be the reference energy for probability pi. However in heterogeneous networks, the value of popt is different according to the initial energy of the node. In two level heterogenous network the value of popt is given by

$$p_{adv} = \frac{p_{opt}}{1+am}, p_{nrm} = \frac{p_{opt}(1+a)}{(1+am)}$$

R denotes total rounds of network lifetime and is estimated as follows:

$$R = \frac{E_{total}}{E_{round}}$$

Etotal is total energy of the network where Eround is energy expenditure during each round.

V. Heterogeneous Wireless Sensor Network Model

1. Two Level Heterogeneous WSNs Model

Two level heterogeneous WSNs contain two energy level of node, normal and advanced nodes. Where, E_o is the energy level of normal node and $E_o(1 + a)$ is the energy level of advanced nodes containing a times more energy as compared to normal nodes. If N is the total number of nodes then Nm is the number of advanced nodes where m refers to the fraction of advanced nodes and $N(1 - m)$ is the number of normal nodes. The total initial energy of the network is the sum of energies of normal and advanced nodes.

$$\begin{aligned} E_{total} &= N(1-m)E_o + Nm(1+a)E_o \\ &= NE_o(1-m+m+am) \\ &= NE_o(1+am) \end{aligned}$$

The two level heterogeneous WSNs contain am times more energy as compared to homogeneous WSNs.

2. Three Level Heterogeneous WSN Model

Three level heterogeneous WSNs contain three different energy levels of nodes i.e normal, advanced and super nodes. Normal nodes contain energy of E_o, the advanced nodes of fraction m are having a times extra energy than normal nodes equal to $E_o(1 + a)$ whereas, super nodes of fraction m_o are having a factor of b times more energy than normal nodes so their energy is equal to $E_o(1 + b)$. As N is the total number of nodes in the network, then Nmm_o is total number of super nodes and $Nm(1 - m_o)$ is total number of advanced nodes. The total initial energy of three level heterogeneous WSN is therefore given by

$$p_{adv} = \frac{p_{opt}}{1+am}, p_{nrm} = \frac{p_{opt}(1+a)}{(1+am)}$$

$$E_{total} = N(1-m)E_o + Nm(1-m_o)(1+a)E_o + Nm_oE_o(1+b)$$

$$E_{total} = NE_o(1+m(a+m_ob))$$

The three level heterogeneous WSNs contain (a + mob) times more energy as compared to homogeneous WSNs.

3. Multilevel Heterogeneous WSN Model

Multi level heterogeneous WSN is a network that contains nodes of multiple energy levels. The initial energy of nodes is distributed over the close set $[E_o, E_o(1 + a_{max})]$, where E_o is the lower bound and a_{max} is the value of maximal energy.

Initially, node Si is equipped with initial energy of $E_o(1+a_i)$, which is ai times more energy than the lower bound E_o. The total initial energy of multi-level heterogeneous networks is given by

$$E_{total} = \sum_{i=1}^{N} E_o(1 + a_i) = E_o(N + \sum_{i=1}^{N} a_i)$$

CH nodes consume more energy as compared to member nodes so after some rounds energy level of all the nodes becomes different as compared to each other.

CONCLUSION

We evaluate the performance of Distributed Energy Efficient Clustering algorithms on the basis of stability period, network life time and throughput for heterogeneous WSNs. Different heterogeneous WSN models has been studied.

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